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RESEARCH ON THE DISTRIBUTION OF CHINA'S VIOLENT RAINSTORMS

- Communist China -

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RESEARCH ON THE DISTRIBUTION OF CHINA'S VIOLENT RAINSTORMS

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[Following is a full translation of the Chinese-language monograph Chung-kuo Pao-yu Fen-chu T'u Ti yen-chiu (English version above) edited by the Highways Science Research Office of the Ministry of Communications and printed by Jen-min Communications Press, Peking, 1959, 19 pages.]

TABLE OF CONTENTS

I. GENERAL DESCRIPTIONS

China is an expansive country with great variance in climate; it spans a large area both longitudinally and latitudinally, the innermost area in the west being far distant from the eastern seacoast. Continuous mountain chains contribute to a widely varying topography. The distribution of rainfall is uneven, the southeast tending towards abundant rainfall which gradually decreases towards the northwest. There are more violent rainstorms in the south than in the north, more in the mountain areas than on the plains, and more further inland than on the seacoast. The amount of rainfall during violent rainstorms is generally greater in the south than in the north , and in the east than in the west. Because of the uneven distribution, the maximum amount of rainfall is very difficult to calculate. Adding to this difficulty is the fact that the proper method of making regional divisions of rainstorms is very complicated, in part due to the backwardness of our meteorological hydrology knowledge. With the cooperation of the Academia Sinica, the Institute of Hydraulic Research of the Ministry of Water Conservation and Electric Power, the Institute of Railway Research of the Ministry of Railways, and the instruction of Soviet expert E. B. Pao-erh-ta-k'o-fu /transliteration of Russian name/, we proceeded to work on regulating the regional division of violent rainstorms. The primary motive of our work was to use the map of the distribution of violent rainstorms for design work. In this pioneer work, mistakes and defects are unavoidable, but this situation will be gradually corrected and improved upon with continued practice and the accumulation of experience so that finally a satisfactory method can be derived for the calculation of the amount of rainfall in a small basin.

II. THE PROCESS OF MAKING THE MAP OF DISTRIBUTION OF CHINA'S VIOLENT RAINSTORMS

In 1954, the Institute of Railway Research consigned the Central Meteorological Bureau and Academia Sinica to make the meteorology map. This map was based upon the map of the average amount of rainfall on the day with the most rain each year over a number of years made by the Institute of Railway Research, and upon the meteorology map of the China Gazetteer made by Academia Sinica with references to temperature, topo-

graphy, longitudinal and latitudinal position, and precipitation. Thus the whole country was divided into the (1) Northeast Region, (2) Northern Region, (3) Central Region, (4) Southeast Coastal Region, (5) Southwest Plateau Region, (6) Steppe Region, and (7) Desert Region. Every region is further divided into several sub-regions. The divisions were based to a considerable degree upon meteorological data.

In March 1957, expert E. B. Pao-erh-ta-k'o-fu was invited to China to direct the making of the preliminary map of distribution of violent rainstorms. The following process was used:

(A) First Revision of the Map of Distribution of Violent Rainstorms

The revision was based upon the regional meteorology map of the Institute of Railway Research, and upon the amount of daily and monthly rainfall for regional divisions, with references to mountain ranges, topography, and wind direction. The wind direction data was derived from Volume I of the China Meteorology Map (refer to the attached Map I, Frequency of Rainfall and Wind Direction in China). The information pertaining to the amount of daily rainfall was based upon the isopleth map of the average amount of rainfall on the day with the most rain each year over a number of years. The Monthly Rainfall Isopleth Map showed the average amount of rainfall in the months of May, June, July, August, and September (refer to the attached Map II, the General Regions with Monthly Rainfalls of 100 mm, 150 mm, 200 mm, 300 mm, and 350 mm). China is divided into 11 regions (refer to the attached Map III, the First Revised Map of the Distribution of Violent Rainstorms).

(B) The Second Revision of the Map of Distribution of Violent Rainstorms

This revision was based on the one previously revised and various reference materials. It was primarily concerned with comparing the amount of rainfall to the number of rain hours, producing a frequency curve for some regions. The curves were based on the daily amount of rainfall, and the formula ($s= \frac{A}{n}$) for rain density which the Institute of Hydraulic Research used to calculate storms of short duration. Comparisons of the curves of two neighboring regions was done in this manner: for neighboring regions which differed in the same probability and the same amount of time more than 10% in the amount of rainfall, two separate regions were established. If the difference of rainfall was less than 10%, the two neighboring regions were combined into one. If, in comparing the average rainfall of the neighboring regions, the difference was too great or different characteristics were discovered, then each regional division was divided into more regions. For instance, in the first revision, after the Ninth and Tenth Violent Rainstorm Regions were compared, they both were established as separate regions. Based on the 24-hour mean value isopleth and wind direction, the Eleventh Violent Rainstorm Region of the first revision was further divided into the 15th and 16th Violent Rainstorm Regions in the second revision. Thus,

18 violent rainstorm regions in the second revised violent rainstorm regional plan were formed (refer to the attached Map IV, the Second Revision of the Map of Distribution of Violent Rainstorms).

(C) The Final Map of Distribution of Violent Rainstorms

After the two above-mentioned revisions, we worked jointly with the Ministry of Water Conservation and Electric Power, Hydraulic Power Bureau, and the Institute of Meteorology to collect rainfall data of the whole country in order to make a Rainfall - Rain Hours - Frequency Curve.

(1) The Collection of Rainfall Data

The method adopted for copying and regulating rainfall data may be found in Reference Book No.10, Report on Regulating the Rainfall Data from 1917 to 1951 in China. Before 1954, the rainfall data was fundamentally based upon the collection of 326 station-years of the Institute of Railway Research. We collected rainfall data throughout the country excepting Sinkiang, Tibet, Hainan Island and Taiwan. This was a momentous achievement considering the expansive area which had to be copied by the dispatched personnel of the former branch institutes of Highway Design and arranged by the Institute of Highway Investigation and Design. During the period of copying, cooperation was obtained from related Institutes of Railway Design. For example, the Institute of Meteorology helped to regulate and copy data for approximately 100 station-years. We collected data for a total of 2,120 station-years, and adopted a total of 2,014 station-years of recorded rainfall data. The adopted data for the station-years are shown in Table 1.

Table 1 The Station-years of the Various Regions

Region Number	Station-years
1	60
2	82
3	62
4	326
5	210
6	296
7	174
8	97
9	44
10	94
11	82
12	44
13	118
14	57
15	35
16	142
17	50
18	41

Total of 2,014 station-years

(2) The Making of the Rainfall-Rain Hours-Frequency Curves

Concrete regulating methods were introduced in the contents of Nos. 1, 2, and 3 of the reference books. We will only briefly introduce the method and actual work situation:

a. Data on the number of rain hours from reference materials and Π maximum number of rainfalls were selected, and each year was represented by a number. Therefore, there was a set of rainfall data for each hour of rainfall.

b. The afore-mentioned sets of data were arranged in sequence, in a decreasing scale, and the period of frequency was calculated with the following formula:

$$T = \frac{\Pi + 0.4}{N - 0.3} \quad \text{, where}$$

T was the period of frequency, Π the total of numbers in sequence, and N the particular number in the sequence.

c. Based on selected reference materials, calculation was made using the following formulae recommended by E. B. Pao-erh-ta-k'o-fu [transliteration of Russian name]:

$$C_v = \frac{1}{H_{cp}\sqrt{\Pi - 1}}\sqrt{\Sigma h^2 - \Pi H_{cp}^2}$$

$$C_s = \frac{1}{(\Pi - 1)C_v^3 H_{cp}^3}\left[\Sigma h^3 - 3H_{cp}\Sigma h^2 + 2H_{cp}^2\Pi\right]$$

where h was the maximum amount of rainfall in millimeters, H_{cp} was the average amount of rainfall in millimeters, and was the total number of times.

d. Based on the obtained C_v and C_s, we were able to obtain the distance ϕ from the center of the ordinate along the Pearson III Type Curve from the Foster's Table. From the following formula, we could use the calculations of the amount of rainfall of the various periods of frequency to make a theoretical frequency curve:

$$h = H_{cp}\,(1 + C_v\,\phi)$$

e. The coordinates for making empirical frequency distribution curves on logarithmic paper and for comparisons to theoretical frequency curves, were based upon selected rainfall data and the corresponding frequencies. If the results were not coincident, then we could adjust the related values of C_v and C_s and re-calculate the theoretical frequency curve. The final results certified that the empirical curves

were generally coincident to the theoretical curves.

Used frequency 10^{7} as the maximum value (M.M.), which could be obtained from the graph by extrapolation to 10^{7} on the graph.

During the drawing process, we again adopted the empirical formula for the calculation of the maximum discharge in calculating the theoretical M.M. value:

$$H_{MM} = H_{cp}(1+11\ C_v^{4/3})$$

The results of this formula revealed that, in the brief periods of rain frequency curve, the theoretical H_{MM} calculated from the formula was more or less coincident to the theoretical curve. However, with an increase of rain hours, the value of H_{MM} was generally greater, so we only considered it as the reference point of the extrapolation of the theoretical curve.

The actual maximum rainfall value H_{MM} observed by the Institute of Water Conservation was used as a base to compare the calculations of 1:M.M. curve. We were able to adjust the curve upward or downward to better coincide to the actual situation.

f. The various rainfall frequency curves of the different time divisions were transferred from dual logarithmic paper to ordinary cross paper; then we obtained the rainfall-rain hours-frequency curve.

Thus, we plotted the rainfall-rain hours-frequency curve of 19 violent rainstorm regions (refer to attached Maps VI - XXXII).

Our method of drawing the curves was slightly different from the one described in reference books Nos. 1 & 2. The differences were the following:

(a) In the reference books, the data was obtained by the extension of the curve by utilizing the French curve, but we used the Pearson III Type Curve.

(b) Our method of extending the curve was H_{MM} interpolation. It was not suitable to use H_{MM} extension.

(c) We began with a frequency period of one year, since in a one to two year period, 40% of the points intersected with the curve at different instances.

During the processing of the curve, we realized the following:

(a) The data was not adequately representative of all situations.

Although there were more than 200 station-years represented, the value of C_v was not good enough on some curves. Generally, the relation between C_v and C_s was adequate.

(b) Although we adopted the H_{MM} extension curve, yet we were unable to apply the curve in all cases; sometimes we only used H_{MM} as the reference point. Thus, on curve extension, there was a certain degree of subjectivity.

(3) The Adjustment of the Violent Rainstorm Regions

For the comparison of rainfall-rain hours-frequency curves of neighboring regions, the regional division of the second revised map for the distribution of violent rainstorms was fundamentally adequate. The method of comparison was the same as the one adopted in the second revised map. During the comparison process, we discovered that there were a number of frequency curves which were similar and there was very little difference in certain time sections. We used the regular highway-adopted probabilities of 1:15, 1:25, 1:50, and 1:100 and short-rain hours as the standard of comparison. When the difference between these probabilities and short rain hour divisions were greater than 10%, then we established separate regions.

The general results of curve comparison were the following: in some regions, the 1:2 and 1:5 frequency curves did not differ greatly with that of neighboring regions, and some were almost coincident. This phenomenon is reasonable. The frequencies of the most regions were 1:1,000, 1:10,000, and 1:MM-curves that differed more than 10% with that of neighboring regions. This reveals that the amount of rainfall during rare violent rainstorms was very much different. After a comparison based on the curves was made, it was decided that the following regions did not need to be adjusted:

The regional division numbers were based on the second revised draft. We established the First and Second regions based on a comparison of the curves. However, the southern parts of these two regions include a small part of the south bank of the Yellow River, so, after examining the different rainfalls for the south and north banks of the Yellow River, we moved the southern boundaries of these two regions to the Yellow River.

For the Third and Fourth Regions, the rainfall differences of most short rain hours were over 10%. For periods of rain with durations greater than 600 minutes, the difference was less. We considered T'ai-shan Mountain Range in the Shantung Peninsula. Because of the topography, it was necessary to establish an independent region, so we moved the regional boundaries to the Yellow River, the Shu River, and the Grand Canal.

For the Seventh and Eighth Regions, we moved the regional boundaries to the watershed of the Han River and the Chiu-lung River.

Regarding the 10th and 19th Regions, we made Yunnan the 19th Region. A comparison of the curves showed most curves of the two regions with a difference of less than 10%; therefore, these two regions could be combined from the viewpoint of rainfall. However, because of the variance of topography and wind directions, especially since the 19th region is a part of the Hengtuan Mountain Range, it was more appropriate to establish separate regions. Due to the fact that we had no reference data on the northern part, we temporarily considered a North Latitude of 28° as the northern boundary.

When we compared the curves of the Southern Shensi Violent Rainstorm Region as divided by the First Railway Design Institute to that of the 12th Region, we discovered great similarity between the two. Therefore, we decided to extend the 12th Region southward to border on Ta-pa Shan, and to extend it southwestward to include the greater part of the upper streams of the Wei River and the Chia-ling River.

In comparing the curves of the 15th, 17th, and 18th Regions, we discovered a difference of less than 10% between the 15th and 17th Regions. The mountain terrain consisted in the Ch'ang-pai-chan Mountain Range covering the south of the 17th Region. There were no mountains between the 15th and the 17th Regions, topography and wind direction were similar. Therefore, we decided to combine the 17th region with the 15th region. However, because of the mountain range, we extended the 18th Region northeastward to border on Lung-kang Shan.

Pertaining to the 16th Region, the mountain terrain caused us to extend the 16th Region southwestward to include Chinchow.

In effect, by such adjustments, we abolished the 17th Region and added the 11th Region for a total of 18 violent rainstorm regions. The following Table 2 compares the final regional divisions with that of the second revised draft of regional division.

Table 2

Draft of Plan	Regional Divisions																	
Second Revised Draft	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Final Plan	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17		18

The 19th Region of the second revised draft was re-divided into the new 11th Region.

The final results of the research on the distribution of violent rainstorms can be seen in the Map of the Distribution of China's Violent

Rainstorms (attached Map V).

(4) The Boundaries and Scopes of Distribution of Violent Rainstorms

See Table 3 for the respective boundaries and scopes of the various regions:

Regions	Regional Boundaries				Regional Scopes
	East	South	West	North	
First	From the Hai River estuary to the east piedmont of T'ai-hang Shan	Yellow River	Wu-t'ai Shan and T'ai-hang Shan	Yen-shan Mountain Range	Primarily the mountain area east of T'ai-hang Shan, including northwestern Hopeh, northwest corner of Honan, and a small part of eastern Shansi
Second	Yellow River	Yellow River	From the Hai River estuary to the east piedmont of T'ai-hang Shan		The North China Plain, including most of Hopeh, north of Yellow River in Shantung, and a small part of the northeast corner of the north bank of the Yellow River in Honan
Third	Yellow Sea	Hsin-ch'i River	The Grand Canal	Yellow River and Po Hai	Shantung Peninsula, including: most part of Shantung, and a small part of northern Kiangsu
Fourth	Yellow Sea	T'ien-mu Shan, Hwang Shan, Ta-pieh Shan, Ta-hung Shan, and Ching Shan	Wu-tang Shan and Wu Shan	Hsin-ch'i River, Grand Canal, Yellow River, and Sung Shan	Huai River Basin and the plain of lower stream of Yangtse River, including: all Kiangsu, most of Anhwei and Honan, a small part of northern Hupeh, and the southwest corner of Shantung.
Fifth	Wu-i Shan	Ta-yu Ling, and mountains along the provincial boundary of the northern Kwangsi	Wu-ling-shan Mountain Range	Huang Shan, Ta-pieh Shan, Ta-hung Shan, and Ching Shan	The middle stream plain of Yangtse River, including: whole Hunan, parts of Kiangsi and Hupeh, southwest corner of Anhwei, and small parts of Chekiang and Kwangsi

Regions	Regional Boundaries				Regional Scopes
	East	South	West	North	
Sixth	Kua-ts'ang Shan and Tai-yun Shan	Lo-fou Shan and Chiu-lien Shan	Wu-i Shan, Ta-1ing and watershed of Pei River and Hsi River	T'ien-mu Shan	Southeast Hilly Region, including most parts of Chekiang, Fukien and Kwangtung, and the southeast corner of Kiangsi
Seventh	East Sea and Taiwan Strait	Watershed of Han River and Chiu-lung River	Kua-ts'ang Shan and Tai-yun Shan	Hangchow Bay	Southeast Hilly Region, including parts of Chekiang and Fukien
Eighth	Watershed of Han River and Chiu-lung River	South China Sea	The National boundary	Lo-fou Shan, Chiu-lien Shan, Yun-k'ai Ta-shan, and Shih-wan Ta-shan	Southeast Hilly Region, including a major part of Kwangtung, and a small part of southern Kwangsi
Ninth	Watershed of Pei River and Hsi River	Yun-k'ai Ta-shan and Shih-wan Ta-shan	Mountain range along 106° longitude	Mountain range along the provinical boundary and Miao-ling	Southeast Hilly Region, including: most part of Kwangsi, and a small part of western Kwangtung
Tenth	Wu-i-shan Mountain Range	Miao-ling and the national boundary	Mountain range along 107° longitude, Ta-lou Shan, and mountain range along 104° longitude	Ta-pa Shan	Yunnan-Kweichow Plateau Region, including all of Kweichow, parts of Shensi, Hupeh, Szechuan, and Yunnan, and northwest corner of Kwangsi

Region	Regional Boundaries				Regional Scopes
	East	South	West	South	
Eleventh	Mountain range along 104° longitude	The national boundary	The national boundary	28° latitude	Yunnan-Kweichow Plateau Region, including: most part of Yunnan, and a small part of Szechuan
Twelfth	Mountain range along 107° longitude	Ta-lou Shan	Ch'a-p'ing Shan, Chiung-lai Shan, Lai-chin Shan, and Ta-hsiang Ling	Mi-ts'ang Shan and Mo-t'ien Ling	Szechuan Basin Region, including: a major part of Szechuan
Thirteenth	Ta-hsing-an Ling, T'ai-hang Shan, Wu-t'ai Shan, Wu-tang Shan, and Wu-shan	Ta-pa Shan	Watershed of the originated mountain range of Lo River and Ching River	Great Wall	Loess Plateau Region, including: most part of Shansi, and parts of Hopeh, Shensi, and Kanshu
Fourteenth	Ta-hsing-an Ling	T'ai-hang Shan and Wu-t'ai Shan	Ho-lan Shan and Liu-p'an Shan	Yin-shan, Hsi-lin-hao-t'e, and the national boundary	North Plateau and Loess Plateau Regions, including: most part of Inner Mongolian Autonomous Region, and small parts of Hopeh, Shansi, and Kanshu
Fifthteenth	Hsiao-hsing-an Ling	The south piedmont of Ta and Hsiao-hsing-an Ling	Ta-hsing-an Ling	National boundary	Parts of Heilungkiang and Inner Mongolia

Region	Regional Boundaries				Regional Scopes
	East	South	West	North	
Sixteenth	National boundary	National boundary, Lung-chiang Shan, Kung-chu Ling, Shuang Shan, and Yen-shan Mountain Range	Ta-hsing-an Ling	National boundary, and the south piedmont of Ta and Hsiao-Hsing-an Ling	Sungari River Plain Region, including: parts of Heilungkiang, Kirin, Liaoning, and Inner Mongolia
Seventeenth	Lung-chiang Shan and Kung-chu Ling	Ch'ien-shan and Liaotung Bay	East piedmont of Ta-hsing-an Ling	Shuang-shan	Liao River Plain Region, including: most part of Liaoning, and parts of Kirin and Inner Mongolia
Eighteenth	Yalu River	West Korea Bay		Lung-kang Shan and Ch'ien Shan	Liaotung Peninsula Region, including a part of Liaoning

Footnote:

(1) For Hai-nan Island, we can use the data of the Eighth Region of Violent Rainstorms; and for Lanchow, we can use data of the Fourteenth Region of Violent Rainstorms

(2) Because the greater portion of floods in the Sinkiang and Tibet regions are caused by melting snow, these two are not included in the regional plan.

(3) No regions are allocated for Taiwan Province and Nansha Islands. (No descriptions of Sisha and Nansha Islands)

(4) Bigger violent rainstorms originate on the windward slope of the mountain area within the regions, and the Rainfall--Rain Hours--Frequency Curves represent the average. We should refer to this data when using the charts. In the present reference materials, these situations are found in those mountain areas south of T'ai-shan, Ta-pieh-shan area, Huang-shan area, Hunan Mountain area, O-mei-shan area, Chiung-lai-shan area, vicinity of T'eng-ch'ung, Heng-tuan Mountain Range, and the mountain area of northwestern Kwangsi.

The coastal area affected by typhoon are often struck by gigantic violent rainstorms on the windward slopes.

III. APPLICATIONS OF THE DISTRIBUTION OF VIOLENT RAINSTORMS

The primary motive for regulating the regional distribution of violent rainstorms is to be able to calculate the violent rainstorm run-off of small basins. This information is of great assistance in the calculation of water discharge in designing small bridges and sluices. The regional distribution of violent rainstorms has the following advantages:

(A) With knowledge of the quantity of run-off of violent rainstorms, we can ascertain the amount of water discharge under any climatic conditions, and the technical standard for any flood surpassing the probability. In addition, this knowledge makes it possible to predict with a fair degree of accuracy the maximum discharge, M.M., of any basin.

(B) A knowledge of the quantity of run-off of the violent rainstorms is helpful in designing small bridges and sluices. Generally speaking, variations in the occurrence of violent rainstorms are more regular than the variations of discharge. Presently, if the small basin discharge data is insufficient and difficulties arise in the calculation, then approximate calculations of the data of violent rainstorms can be made by utilizing the available rainfall data.

(C) With the aid of abundant reference materials, we can draw the violent rainstorm isopleth map and substitute it for the map of the regional distribution of violent rainstorms. Under present conditions, because of the lack of data, we are unable to make any detailed divisions or even to draw a very accurate isopleth. For instance, in a certain area there occurred, for the first time, especially big violent rainstorms. This does not mean that this spot should become an independent region, since neighboring regions did not also have the same occurrences. We cannot construct a detailed isopleth on the basis of the flimsy data which we now have, and hope to obtain any accurate results. In adopting the data of observation years from the observation station and in regulating the frequency period of the regions, provided that the regional topography is not extreme, the frequency of rainfall will be generally uniform throughout the entire region. The frequency period is one of the important indexes of our design work.

Although the regional division of violent rainstorms has its defects, because of the urgent need which construction problems present, we should not wait until research has been completed. The best method of solving the problems is to utilize the present results of scientific research in actual situations to make for practical application. In the initial stages, this method is perhaps more crude. However, with further progress in research, gradual fulfillment of objective conditions, and the accumulation of practical experience, accuracy and the method itself will be improved gradually.

The regional division of violent rainstorms is still crude. In the future we should obtain sufficient rainfall data in relation to the cause of violent rainstorms in order to make more detailed divisions.

Because of a deficiency of comprehension of the rainfall norms of certain areas, we are still unable at present to represent the actual rainfall of particular localities. In practical application, we can adjust the available rainfall data of a particular locality on the basis of available rainfall data from the regional division.

In order to fully take advantage of our calculated discharge information in meeting the needs of the masses, we hope that the transportation divisions of every province and every special district will apply this data to their particular local climatic situation in order to regulate the quantity of run-off of the local area and the local region. Whether or not the region above the level of special district can adopt the station-year method is still under discussion. However, in the monsoon wind region, where the area of rainfall is large, it may be raining throughout the area but in varying degrees. This is to say that maximum rainfall recorded centennially by stations at the centers of violent rainstorms does not hold for the more remote regions where the recorded rainfall may be greater or lesser. Therefore, although causes may be similar, quantity and frequency may vary and can be considered independently.

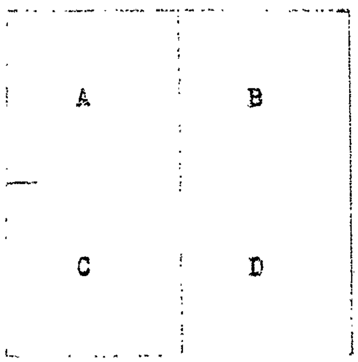
With the concern and leadership of the Party and the assistance from related units, we eventually completed the map of China's regional distribution of violent rainstorms. However, because of the shortage of time and the deficiency in labor, there are many shortcomings and many problems remain. We expect the various fraternal units, practical units, and experts to assist in improving our map of the regional distribution of violent rainstorms by offering their more knowledgeable viewpoints.

After the completion of the research on regional distribution of violent rainstorms, we started to regulate the quantity of run-off of various regions to meet the production requirements. If it is feasible for the transportation units of various areas, they can utilize this information along with knowledge of local characteristics of climate to regulate the regional distribution and quantity of run-off of their particular areas.

IV. APPENDIX

(A) The related Maps of Distribution of Violent Rainstorms (refer to the five maps)

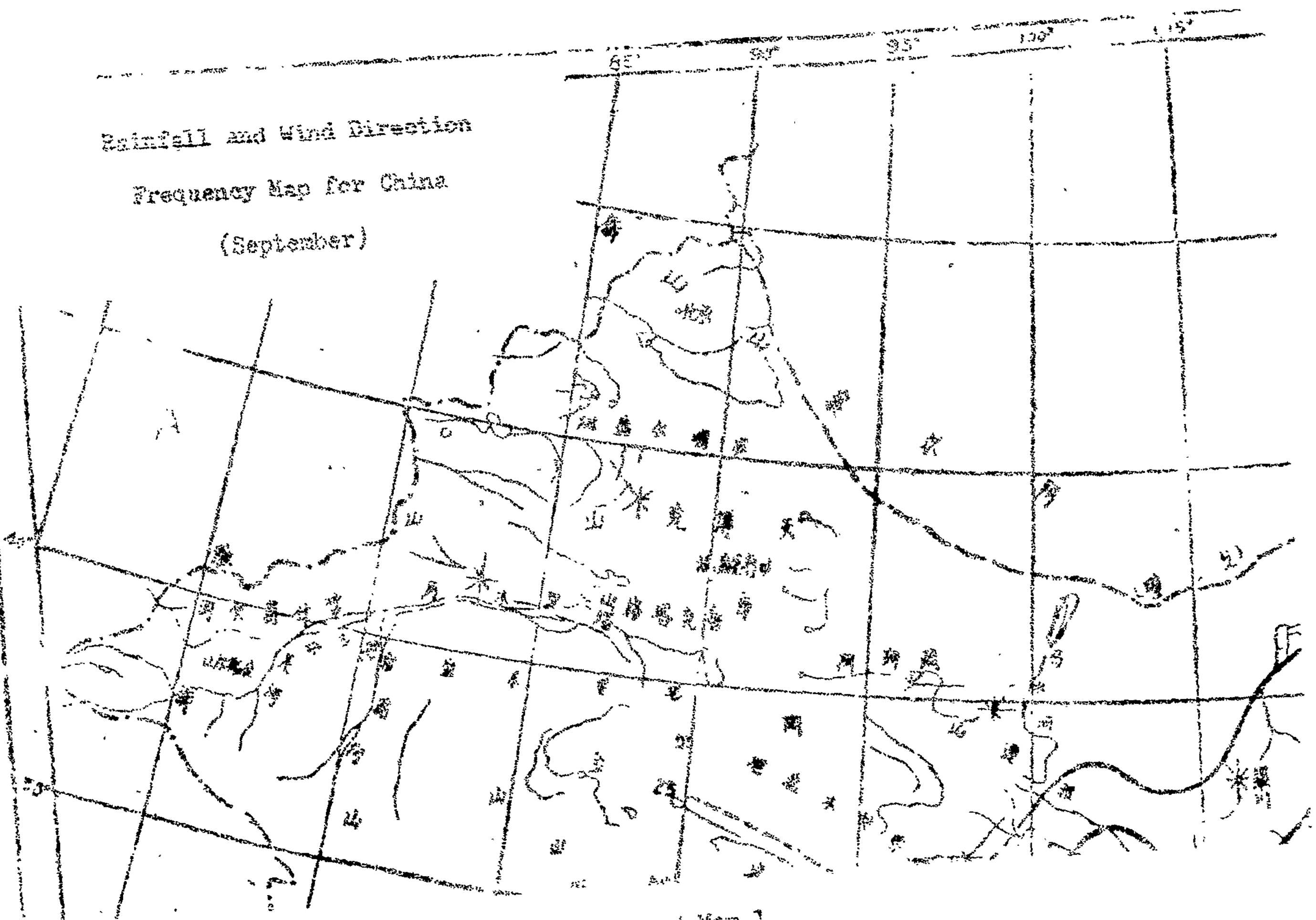
[Individual maps have been divided into four sections and sequence of arrangement should be in the order below]



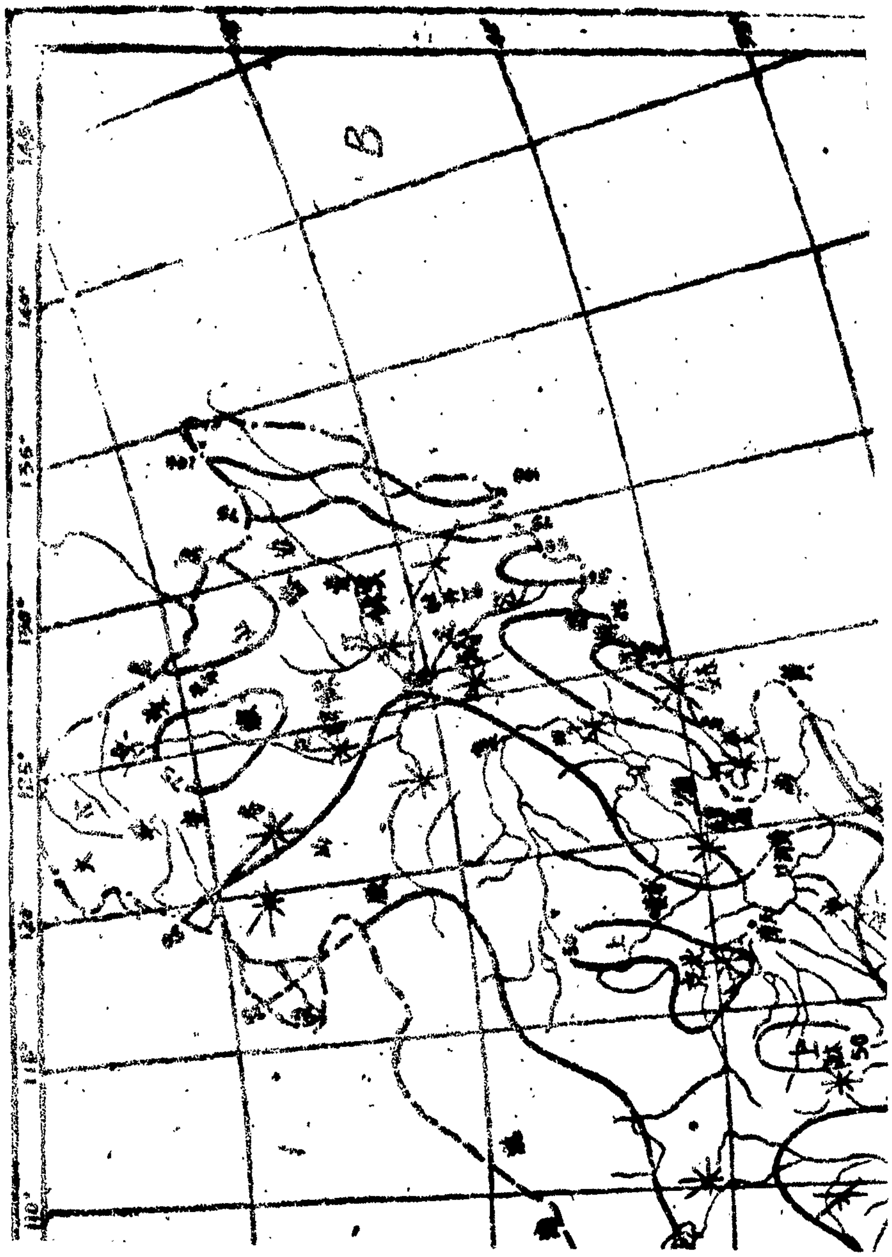
Rainfall and Wind Direction

Frequency Map for China

(September)



Attached Map 1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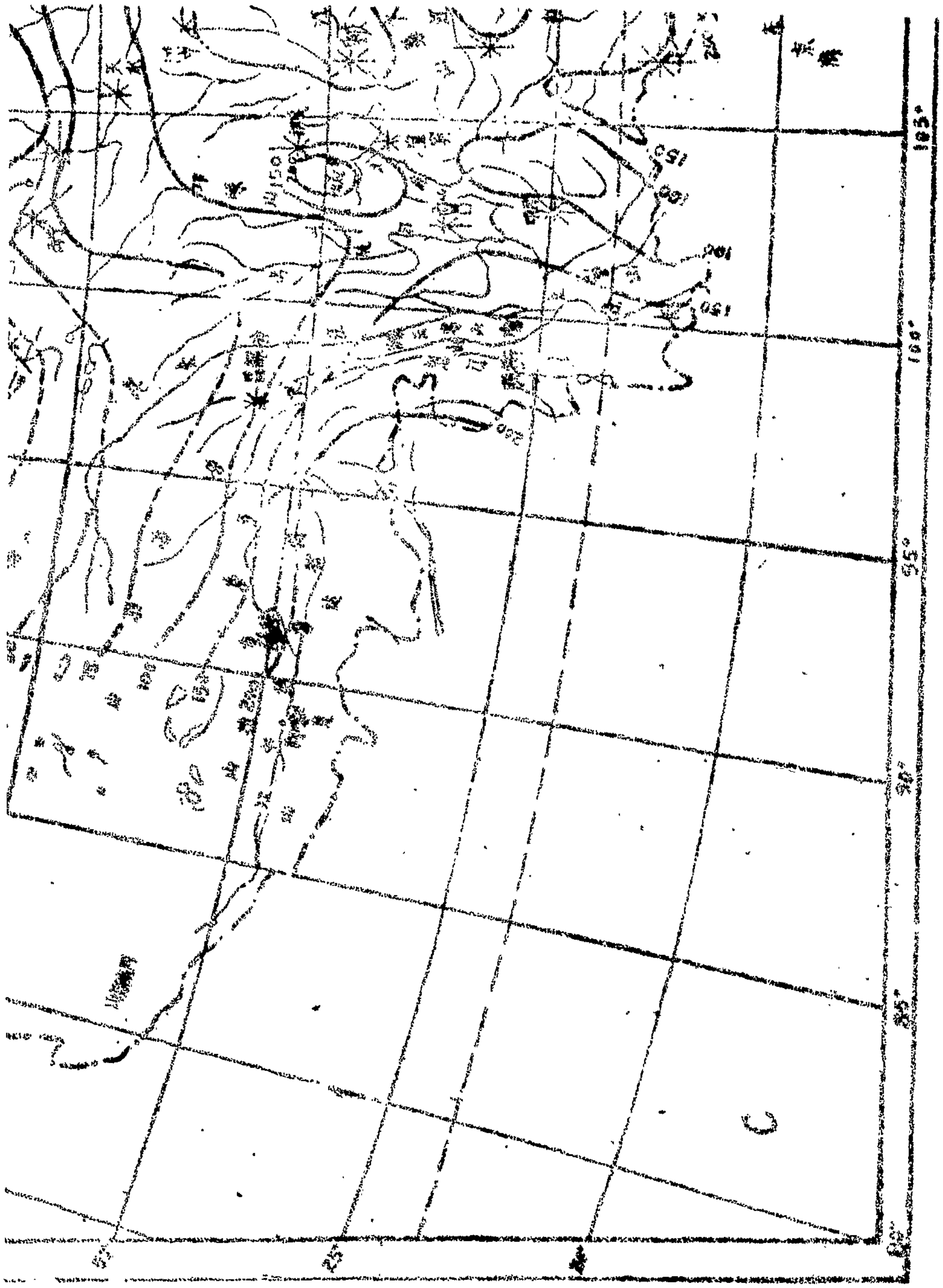
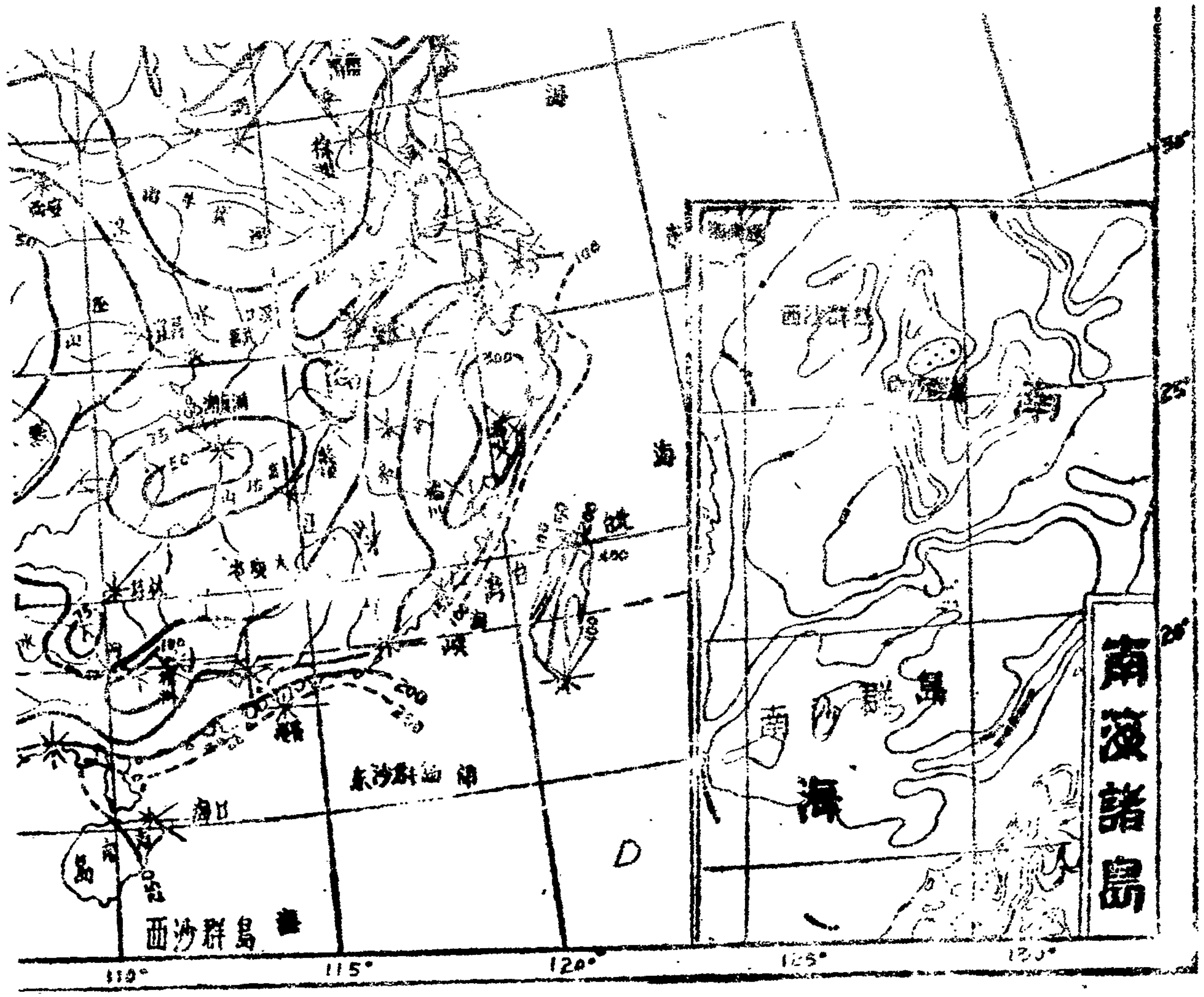
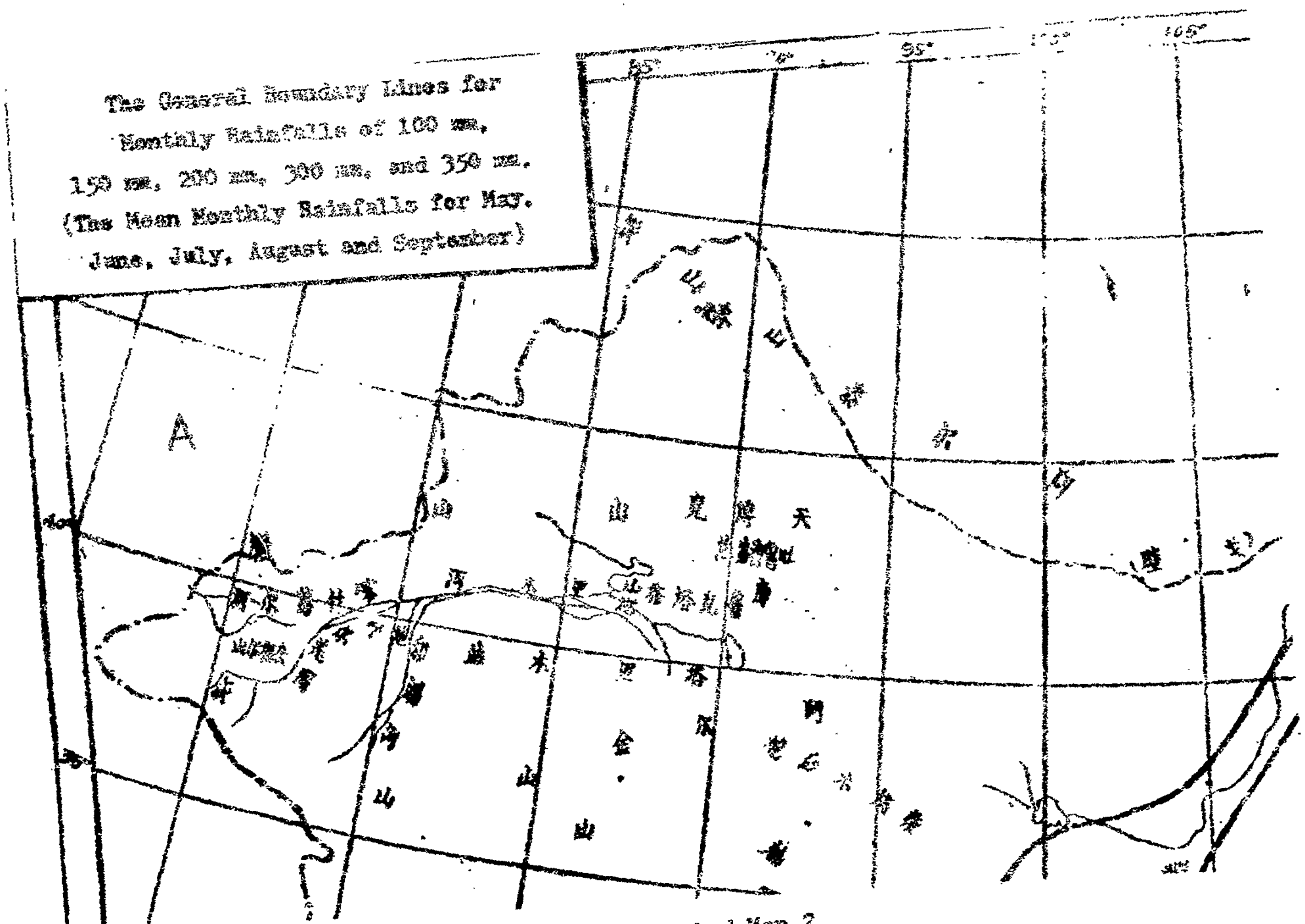




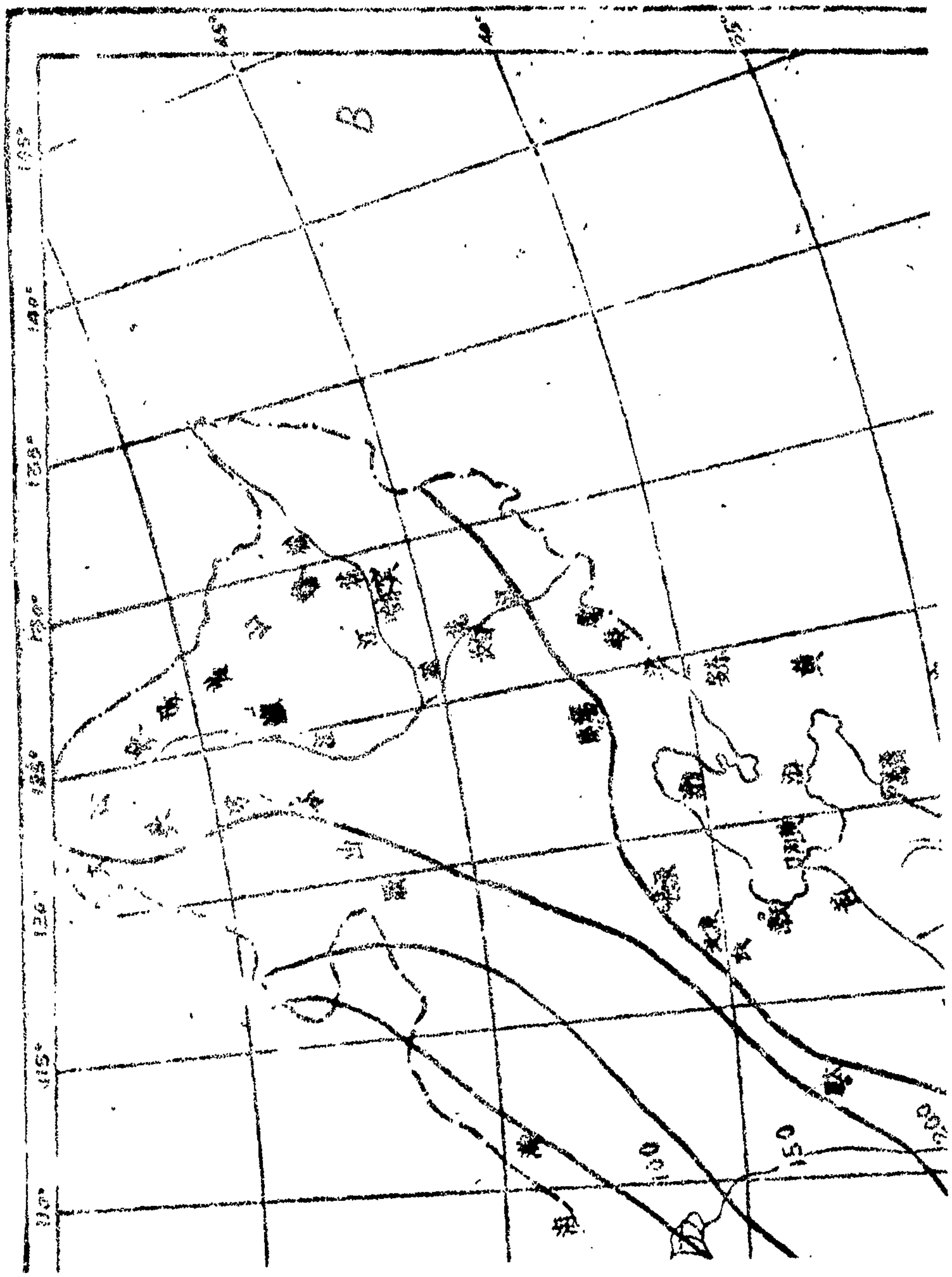
Legend: —·— National Boundary

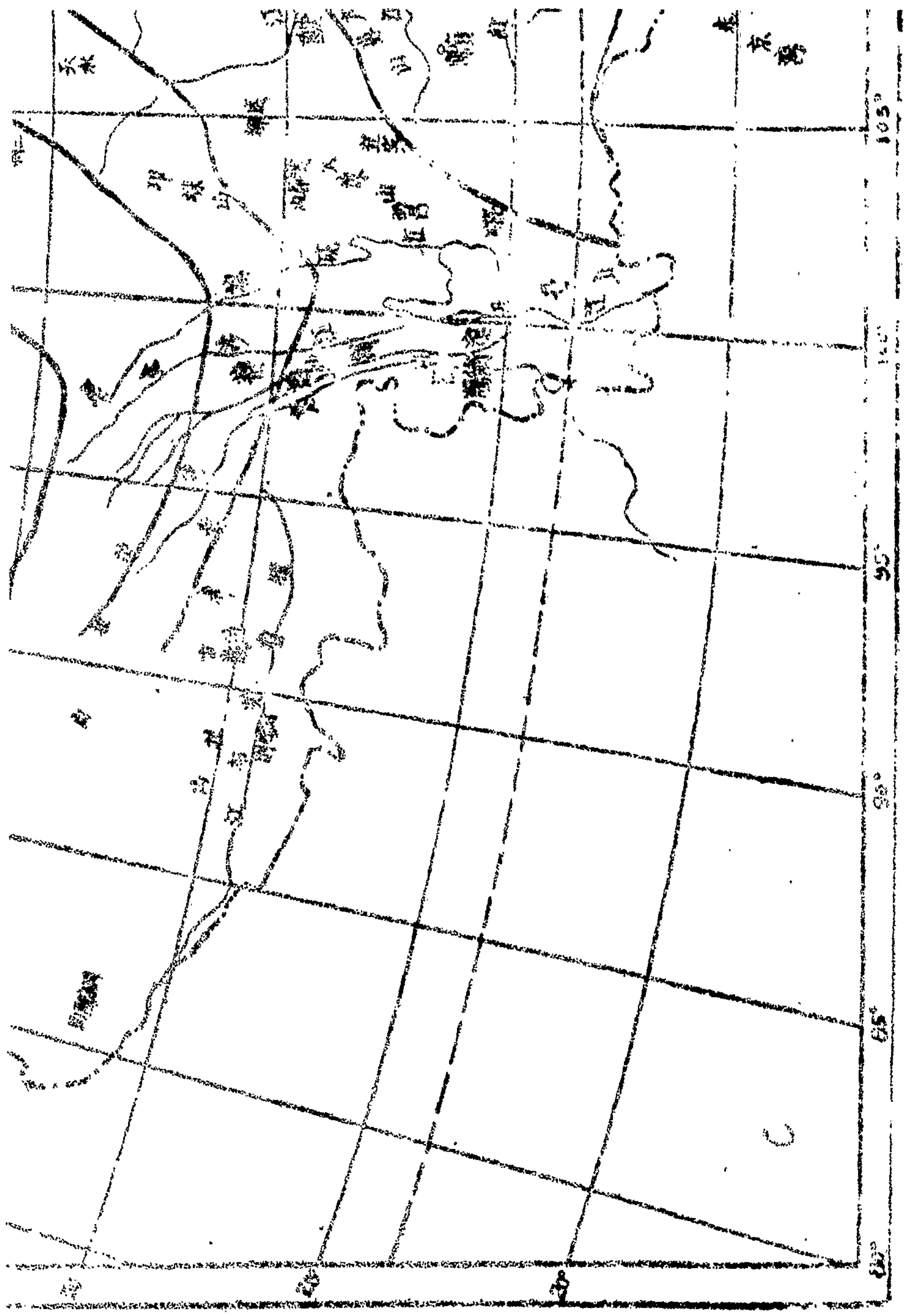
— — —Undefined National Boundary

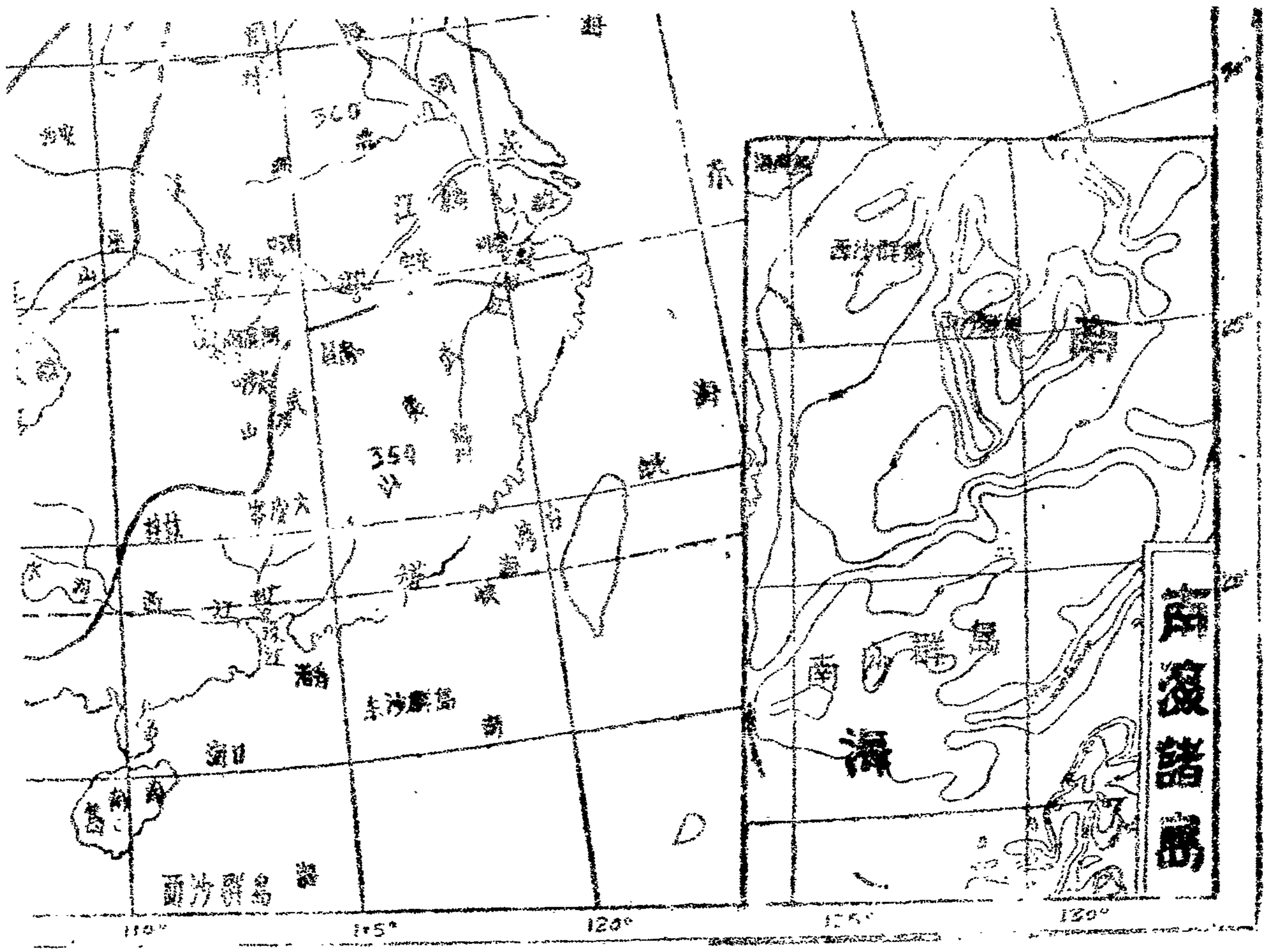


The General Boundary Lines for Monthly Rainfalls of 100 mm, 150 mm, 200 mm, 300 mm, and 350 mm.
(The Mean Monthly Rainfalls for May, June, July, August and September)

Attached Map 2



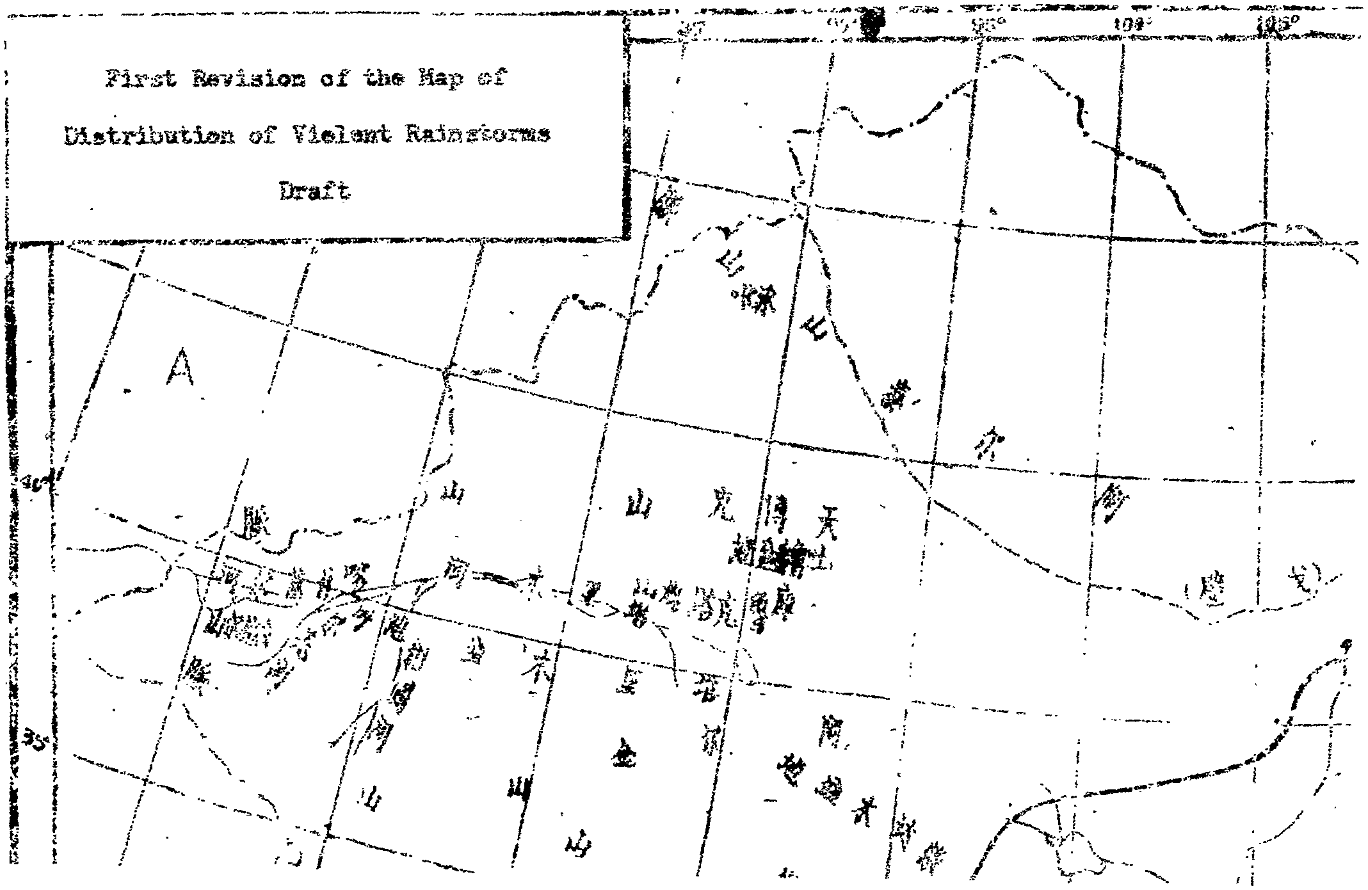




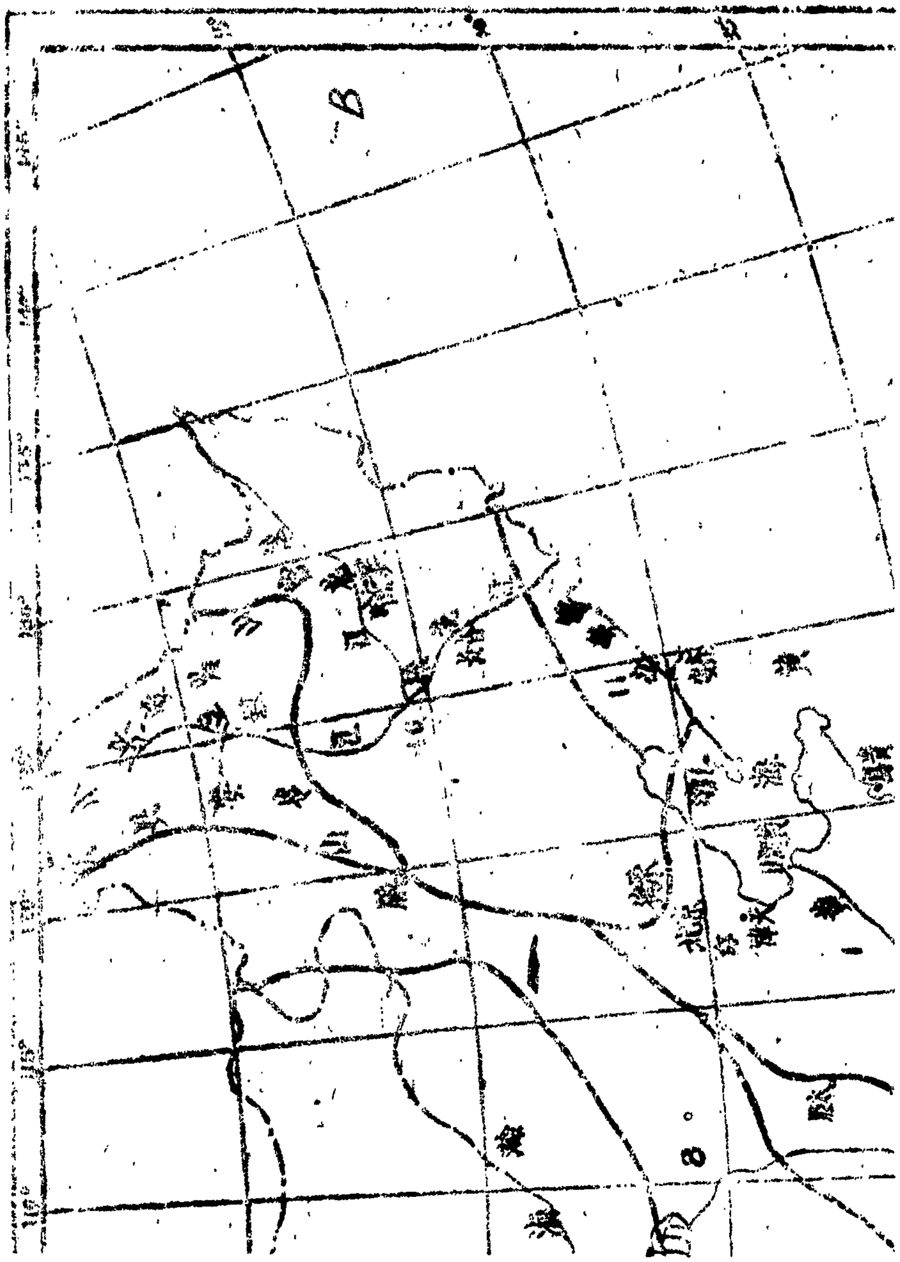
Legend: — · — · National Boundary

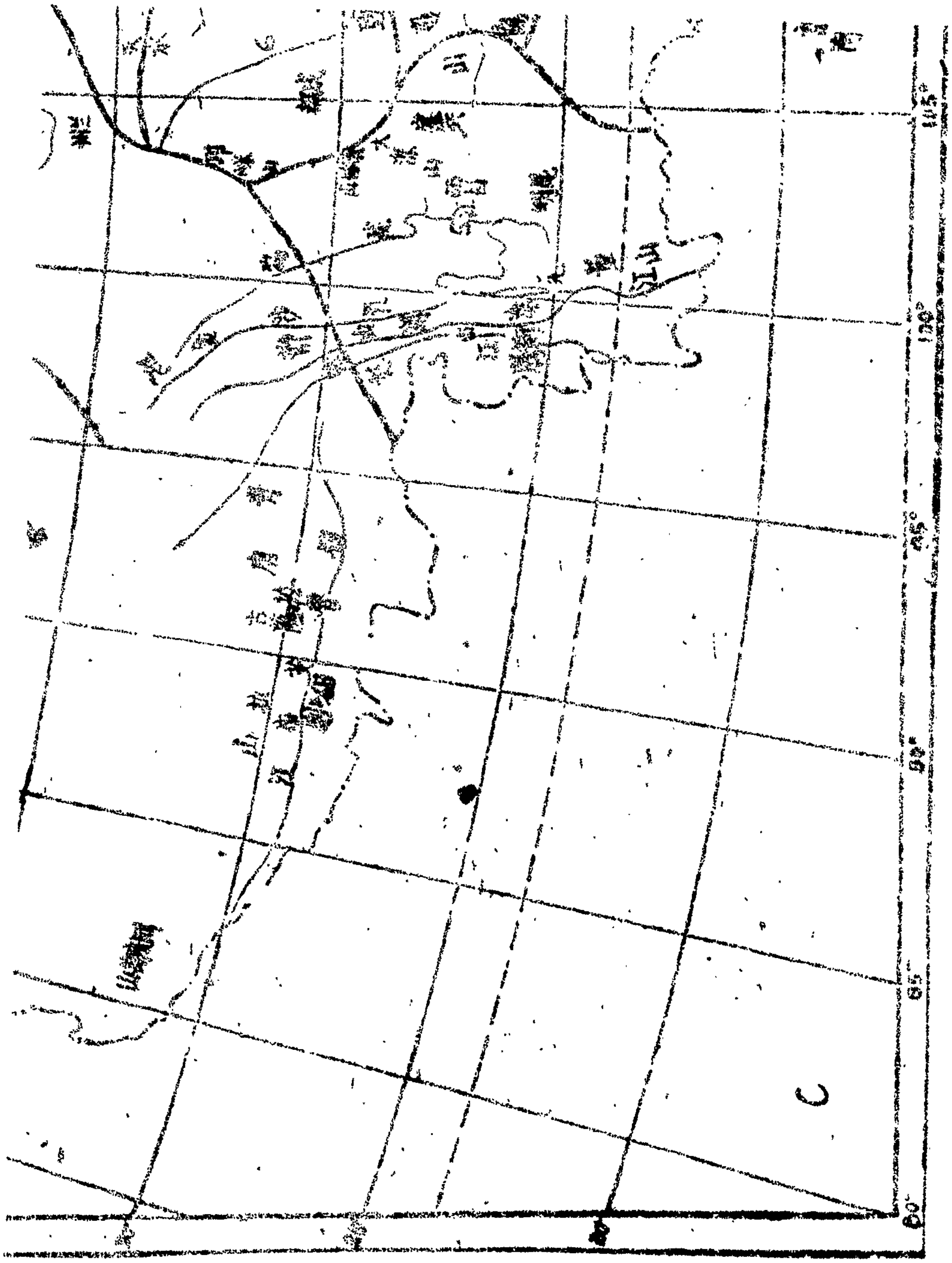
— — — Undefined National Boundary

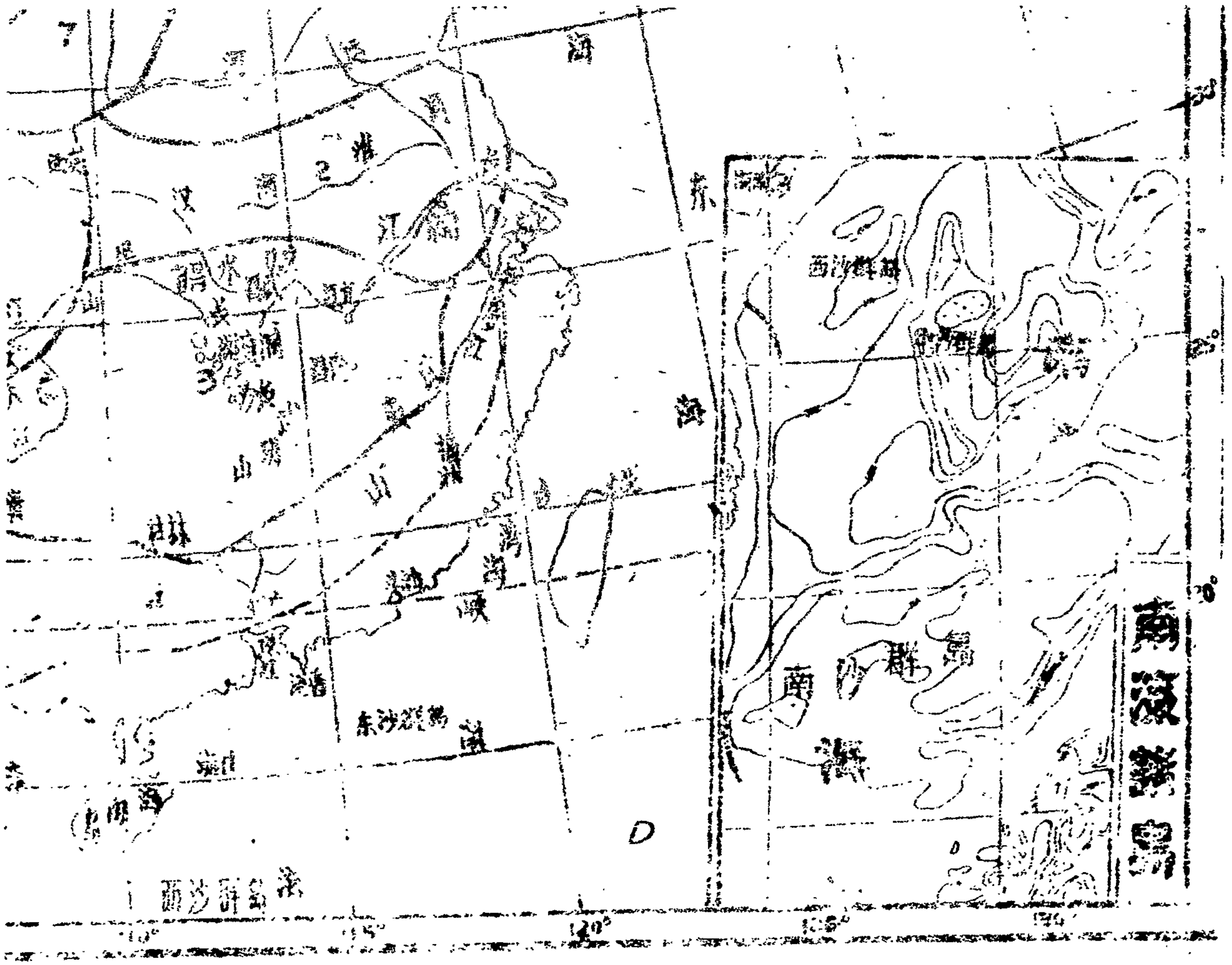
First Revision of the Map of
Distribution of Violent Rainstorms
Draft



Attached Map 3







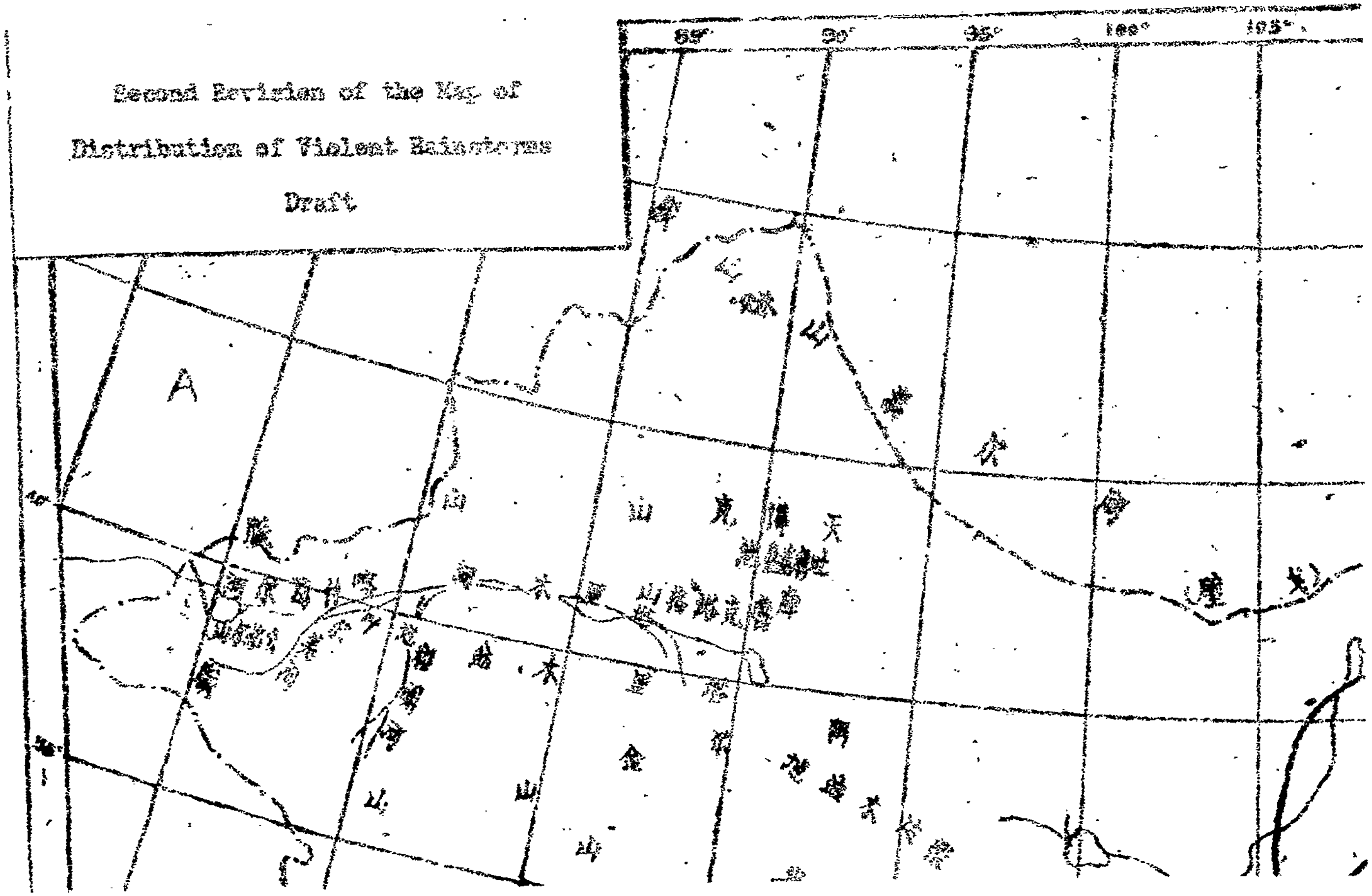
Legend: - - - · National Boundary

— — — Undefined National Boundary

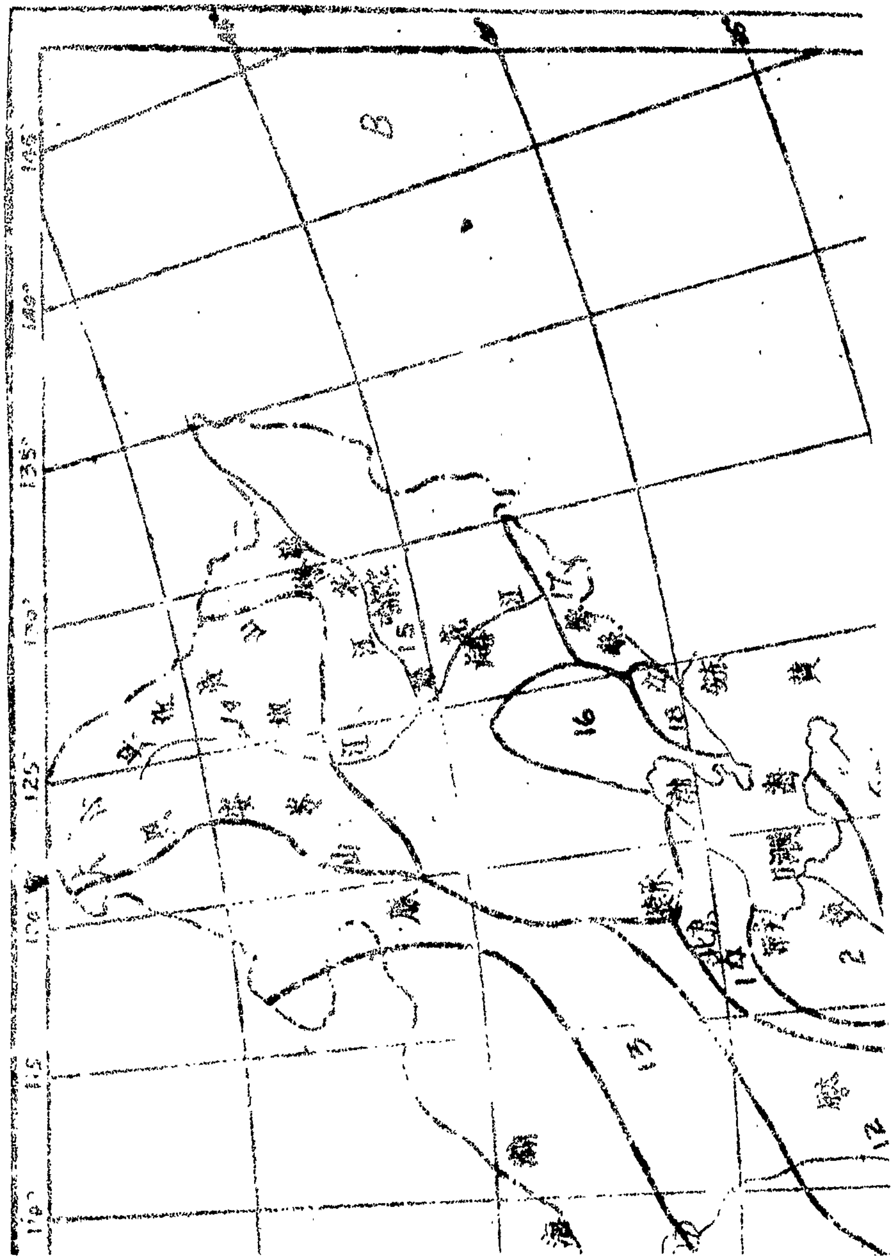
Second Revision of the Map of

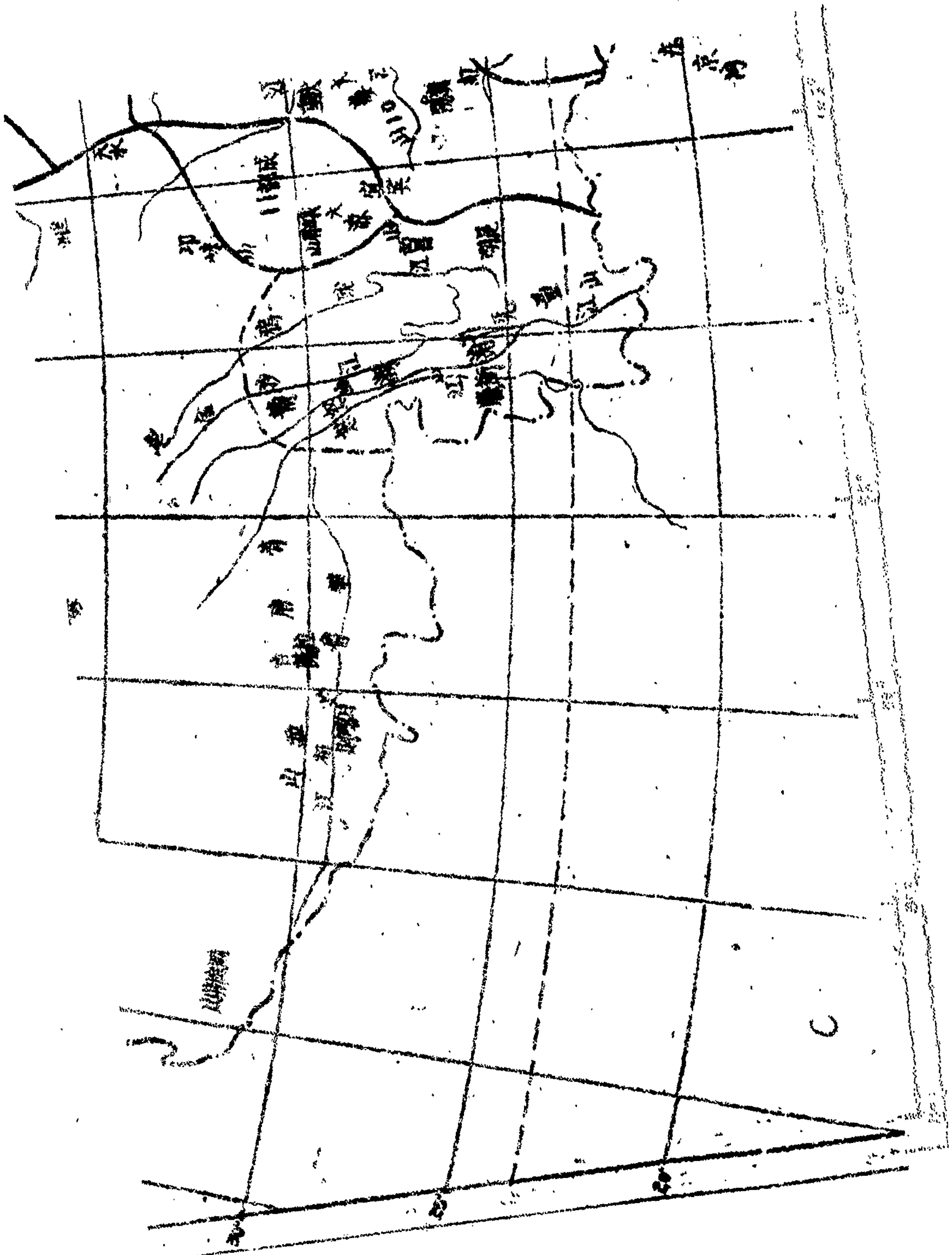
Distribution of Violent Rainstorms

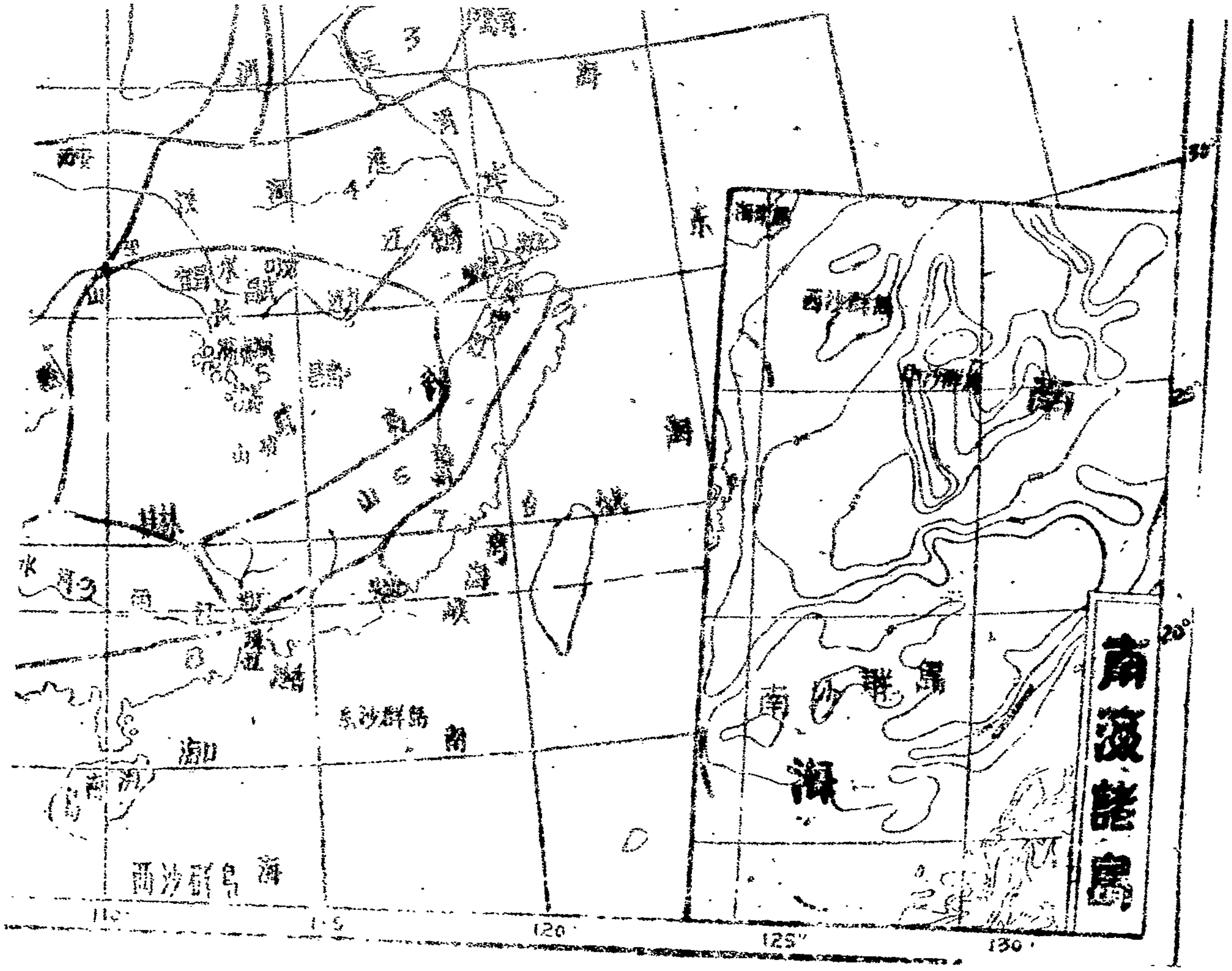
Draft



Attached Map 4



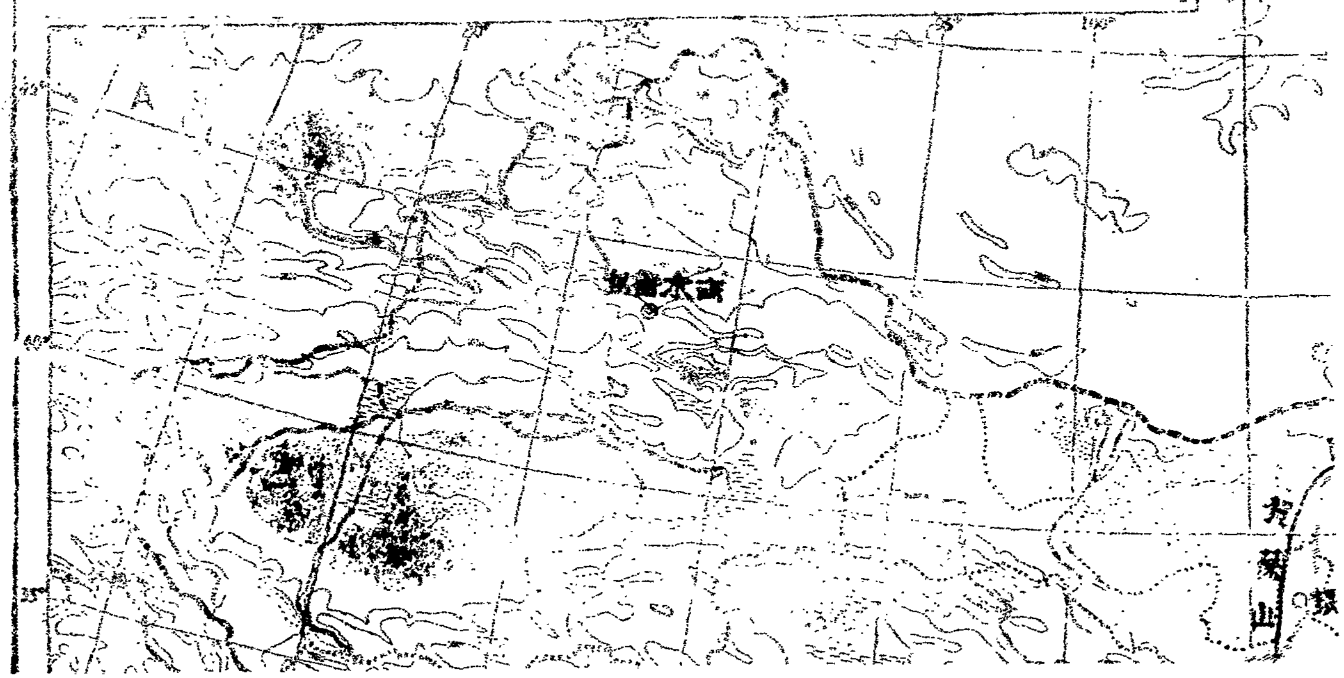




Legend: — · — · National Boundary

— — Undefined National Boundary

The Map of Distribution of China's Violent Rainstorms



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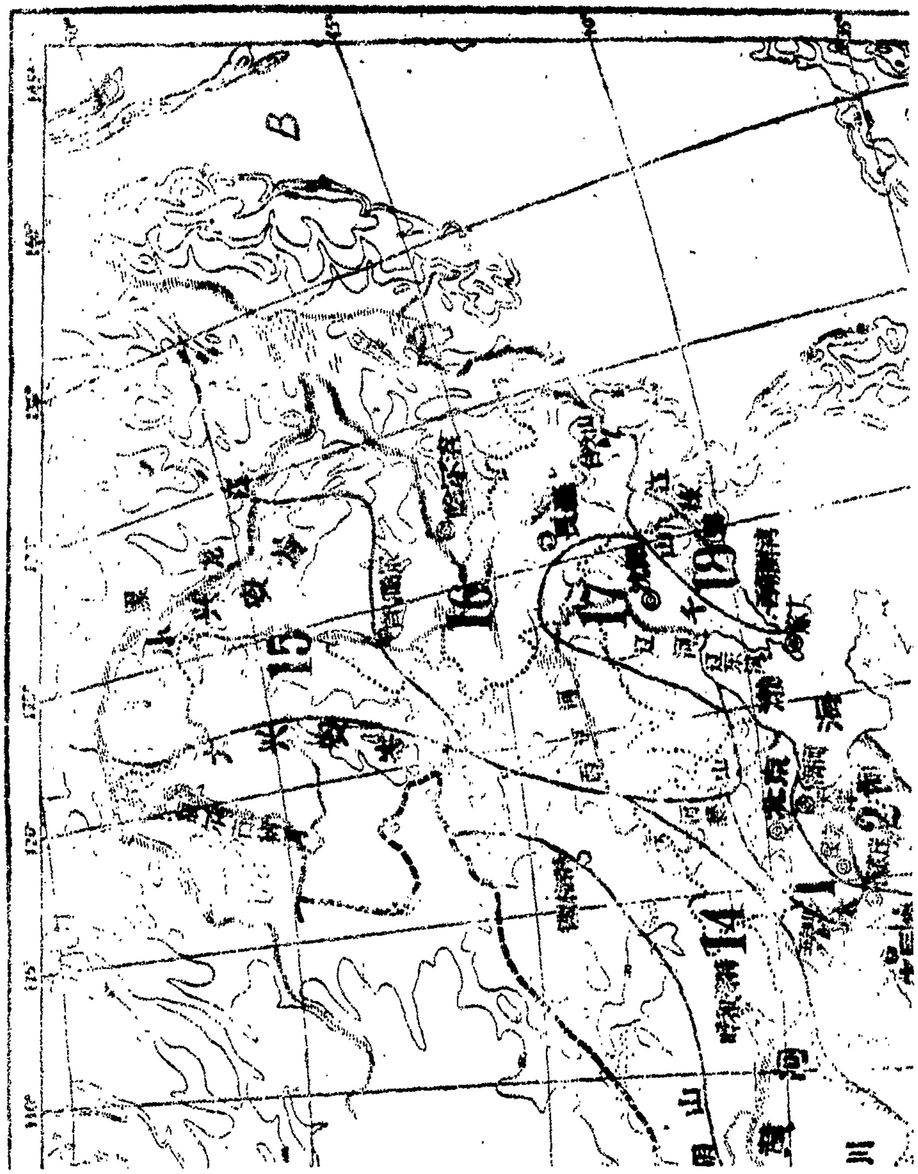
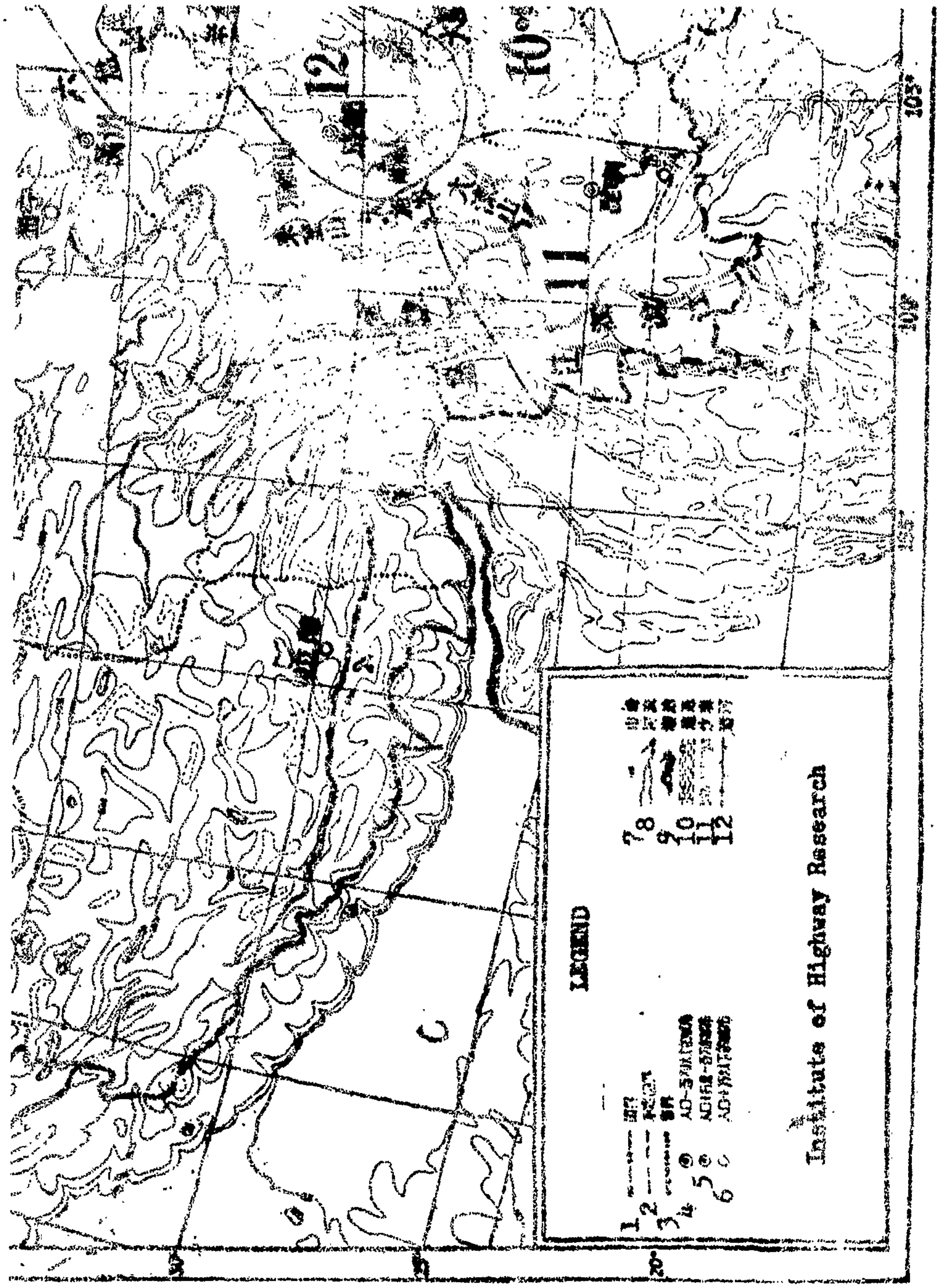
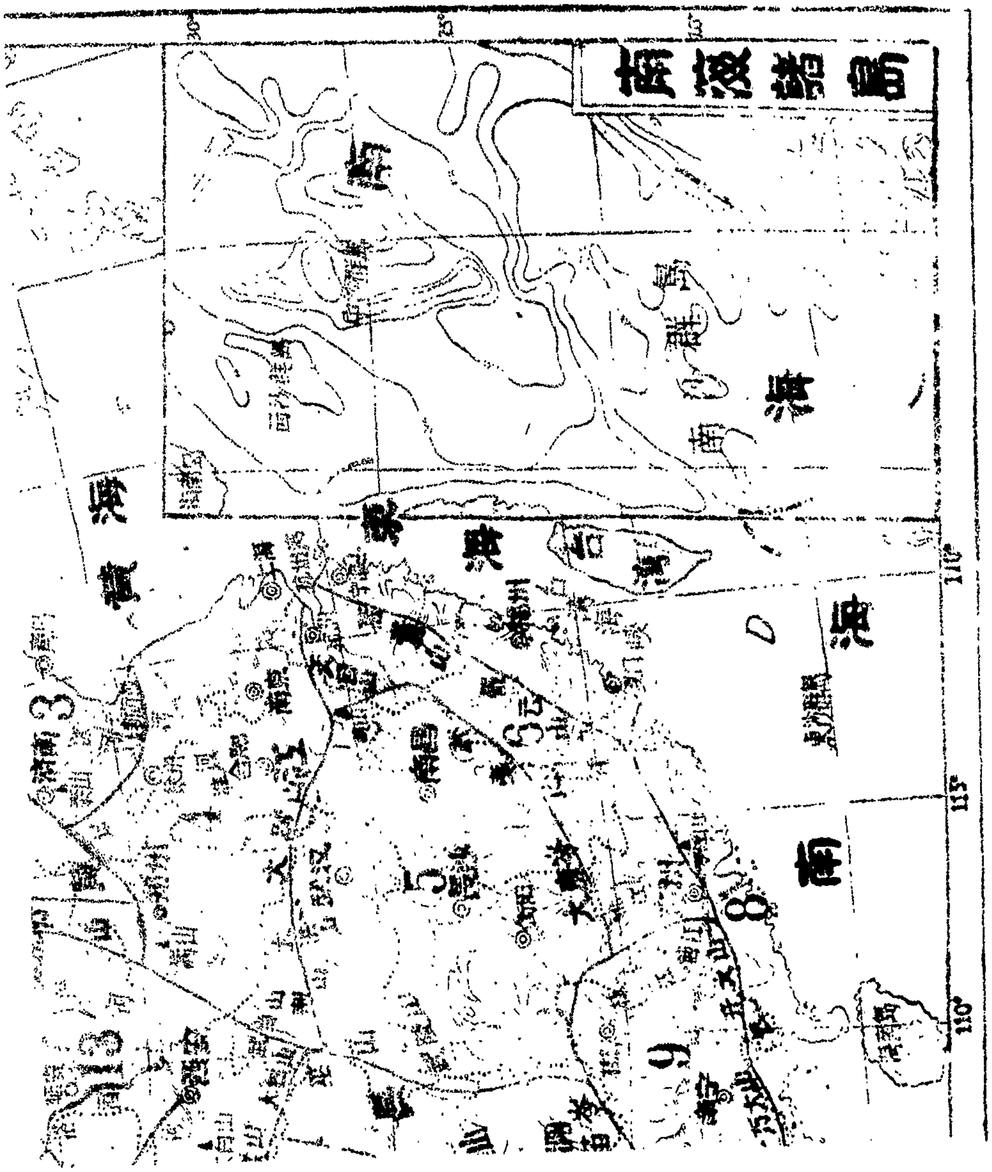


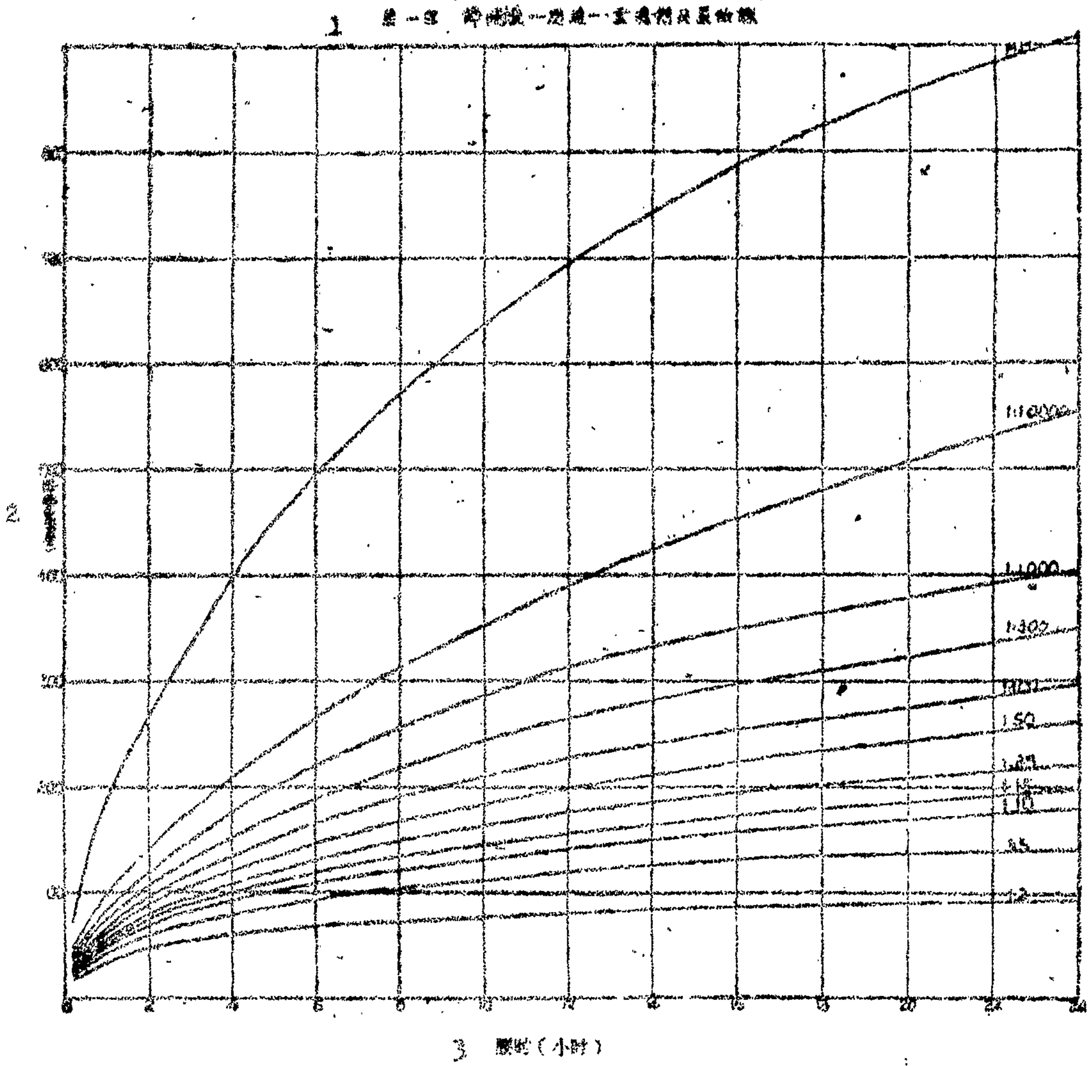

LEGEND
Institute of Highway Research

LEGEND

1. National Boundary	7. Mountain Peak
2. Undefined National Boundary	8. River
3. Provincial Boundary	9. Lake
4. City Population over 1,000,000	10. Marsh
5. City Population between 100,000 and 1,000,000	11. Desert
6. City Population below 100,000	12. Canal

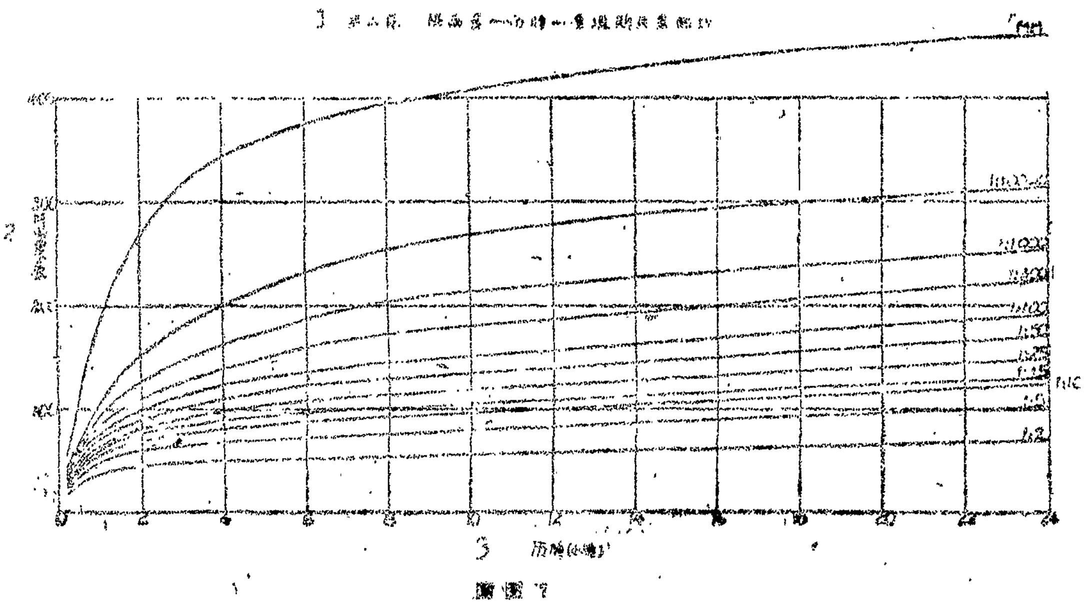


(B) Eighteen Charts of Distribution of Violent Rainstorms for Rainfall-Rain Hours-Frequency Curves



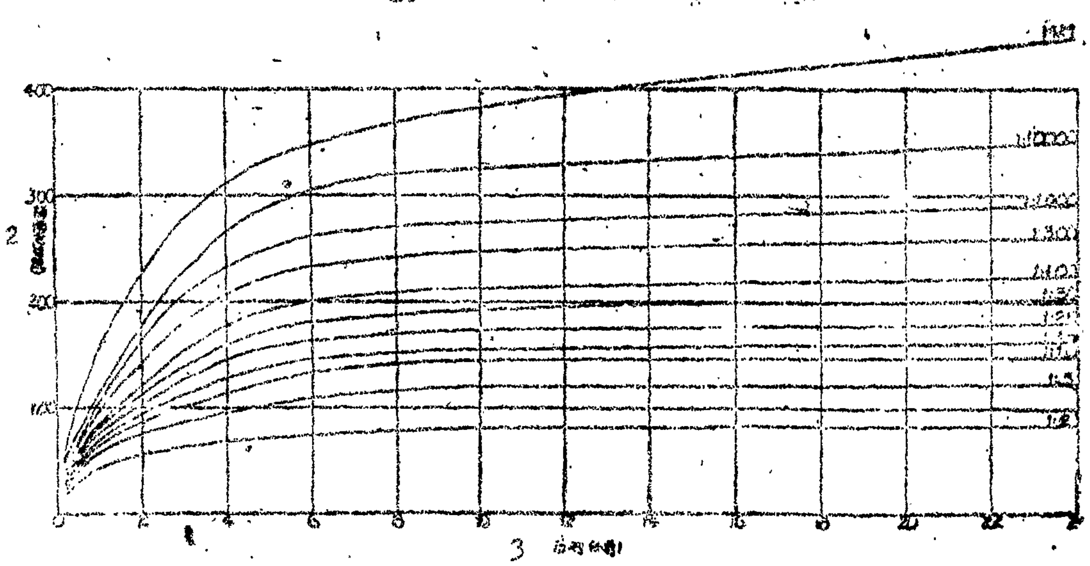
1. First Region   Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Millimeter)
3. Rain Hours

Attached Map 6



1. Second Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter.)
3. Rain Hours

Attached Map 7

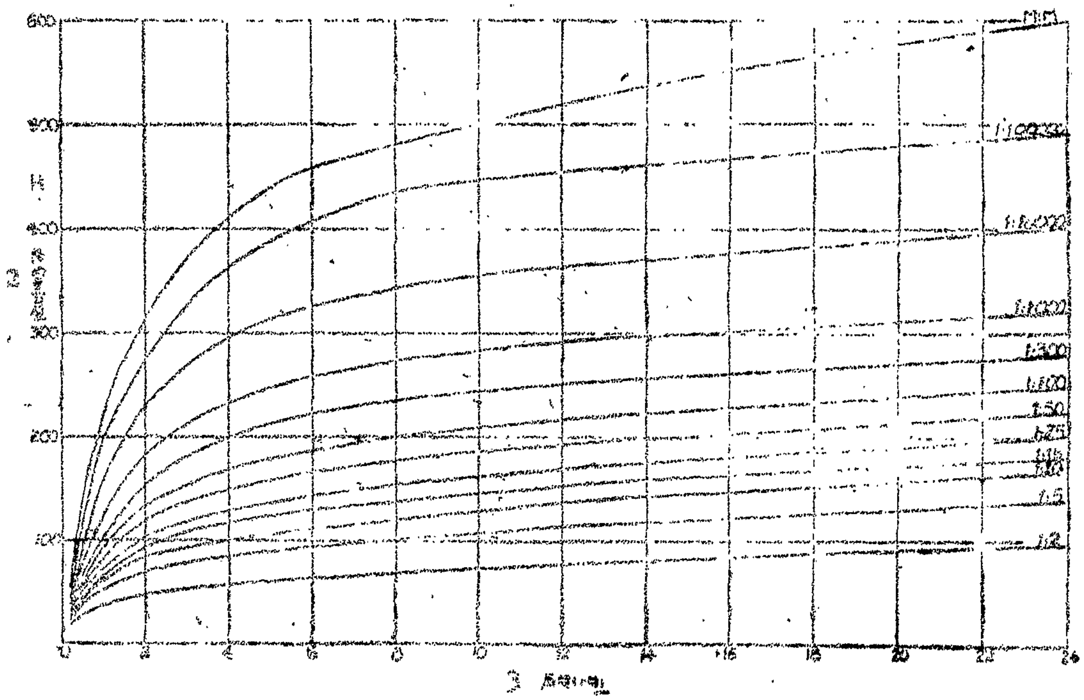


附 图 8

1. Third Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter.)
3. Rain Hours

Attached Map 8

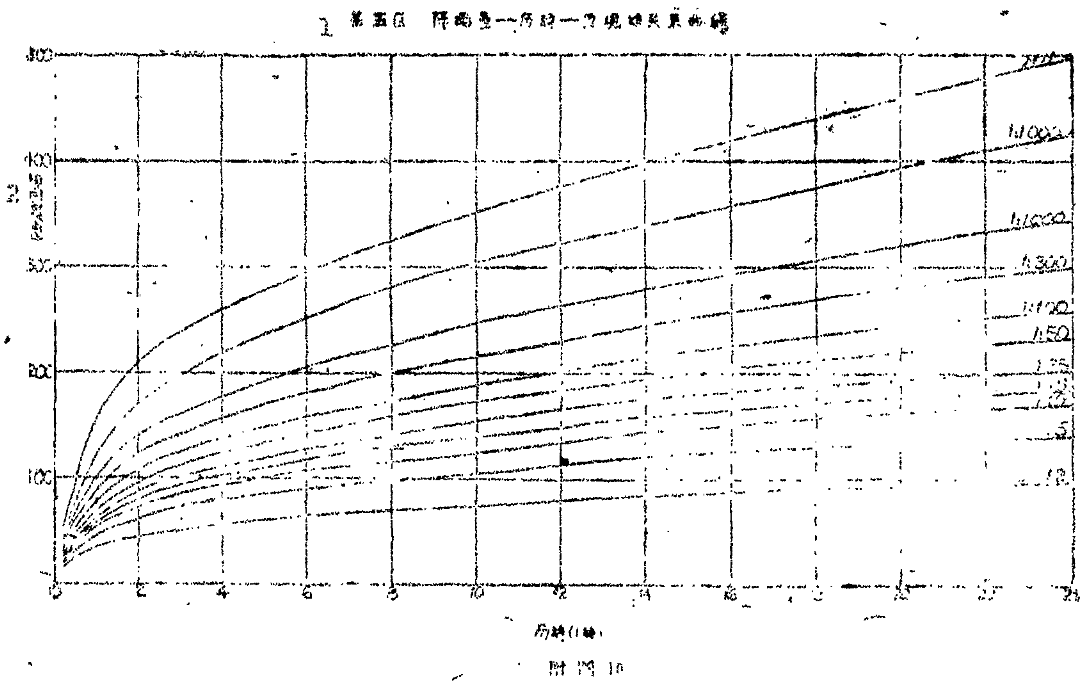
1 第四区 降雨量—雨時—頻度関係曲線



附圖 8

1. Fourth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meters)
3. Rain Hours

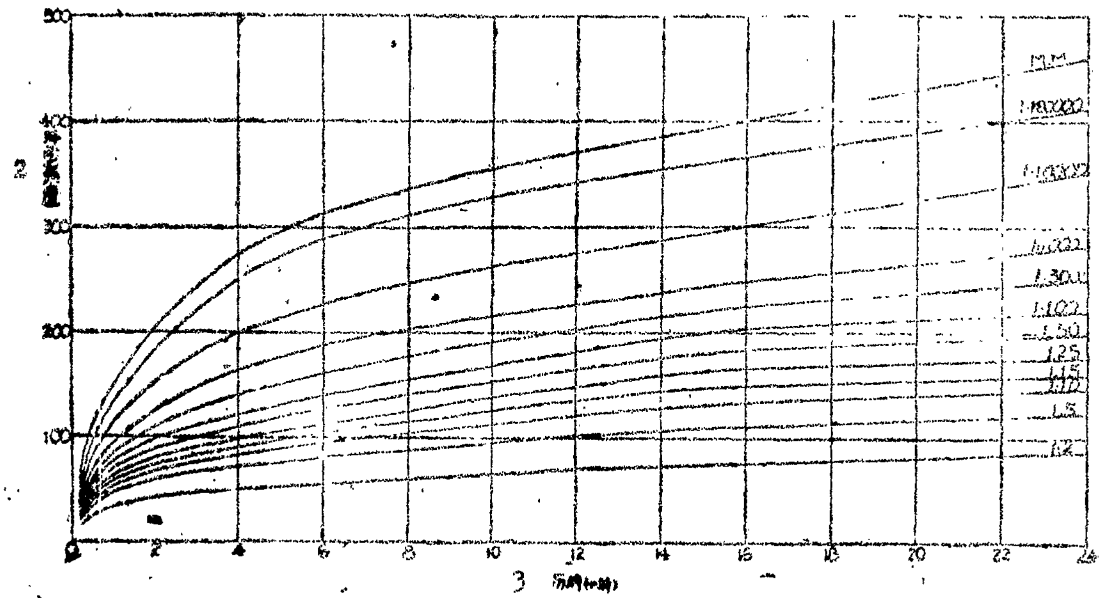
Attached Map 9



1. Fifth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 10

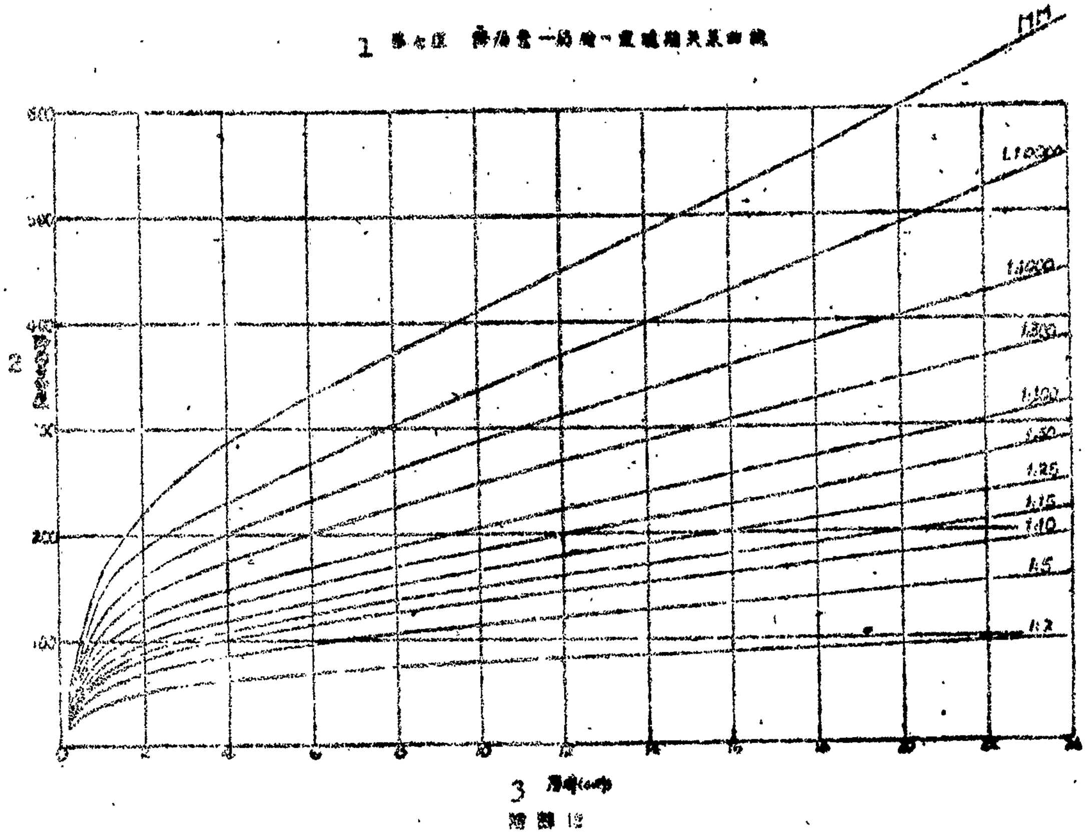
1 第六區 降雨量—歷時—發現頻度曲線



附圖 11

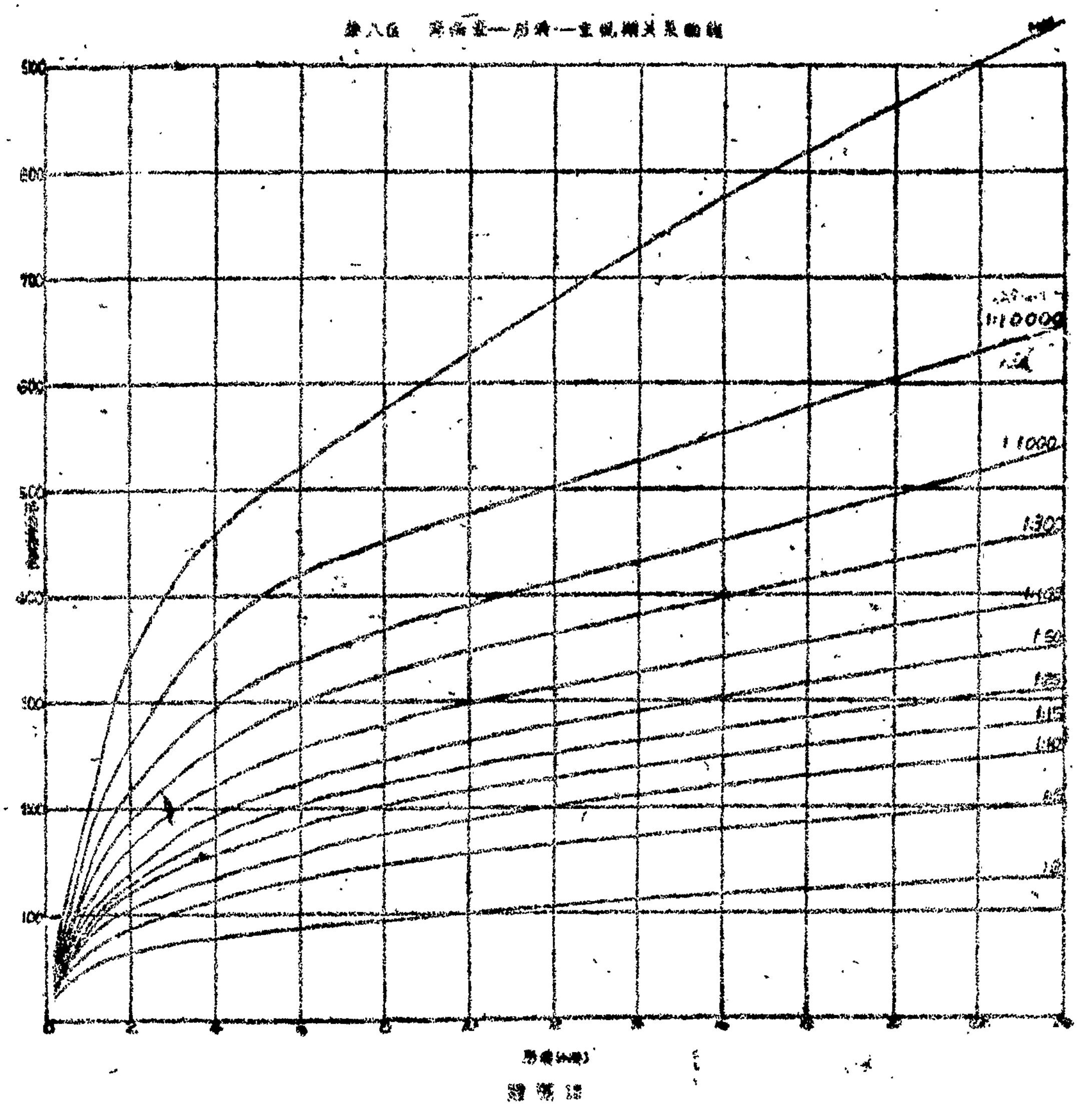
1. Sixth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 11



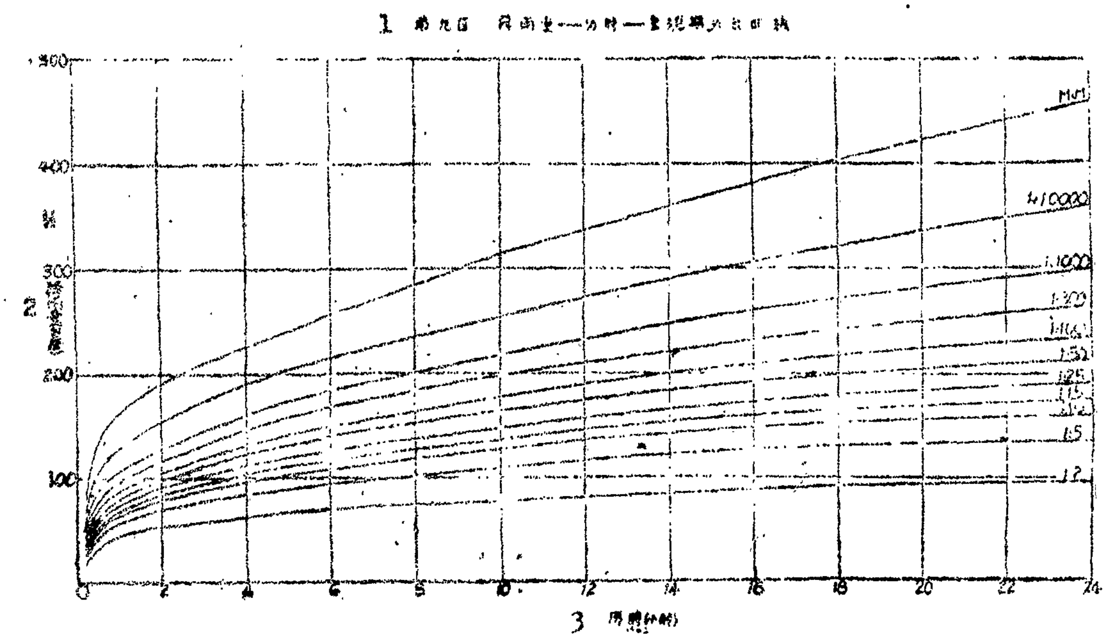
1. Seventh Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 12



1. Eighth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

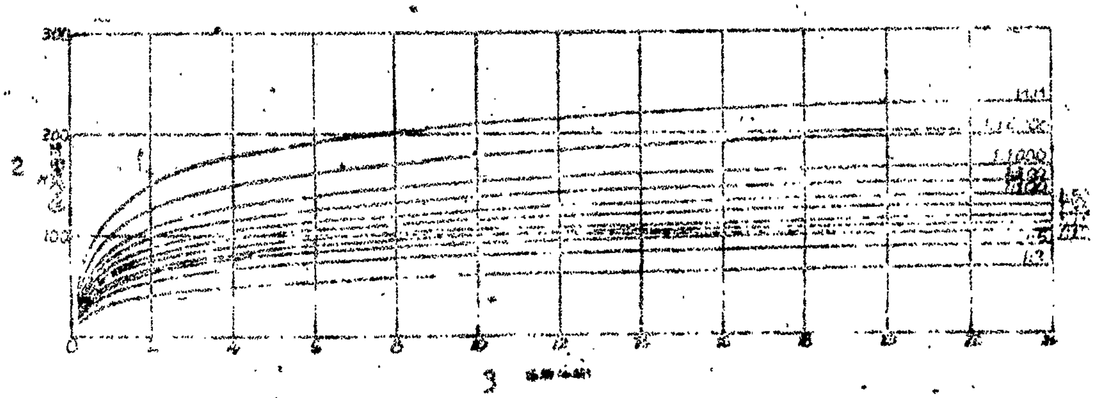
Attached Map 13



附圖 14

1. Ninth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

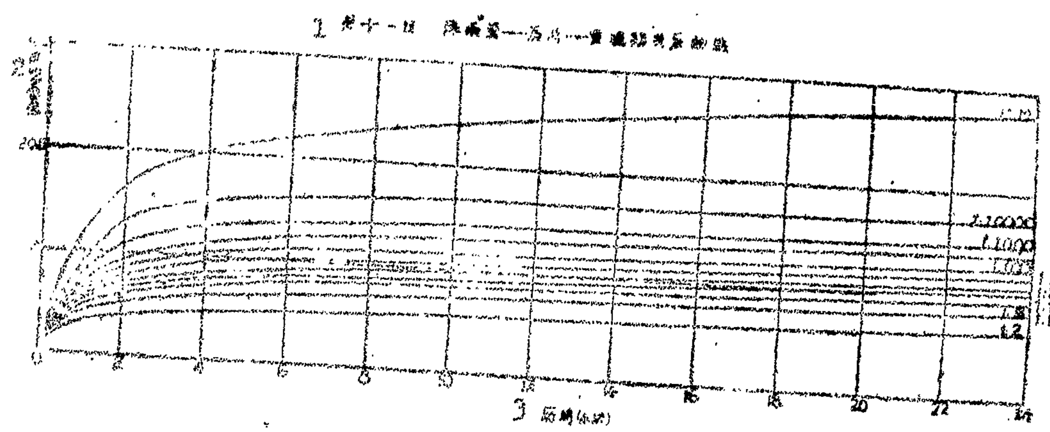
Attached Map 14



附圖 15

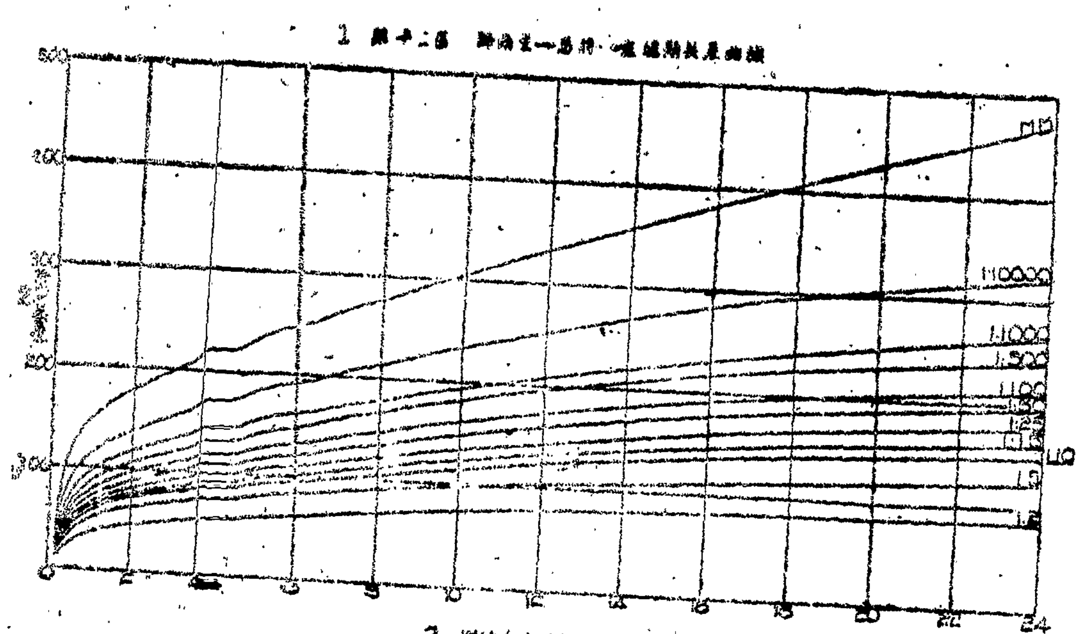
1. Tenth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 15



1. Eleventh Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

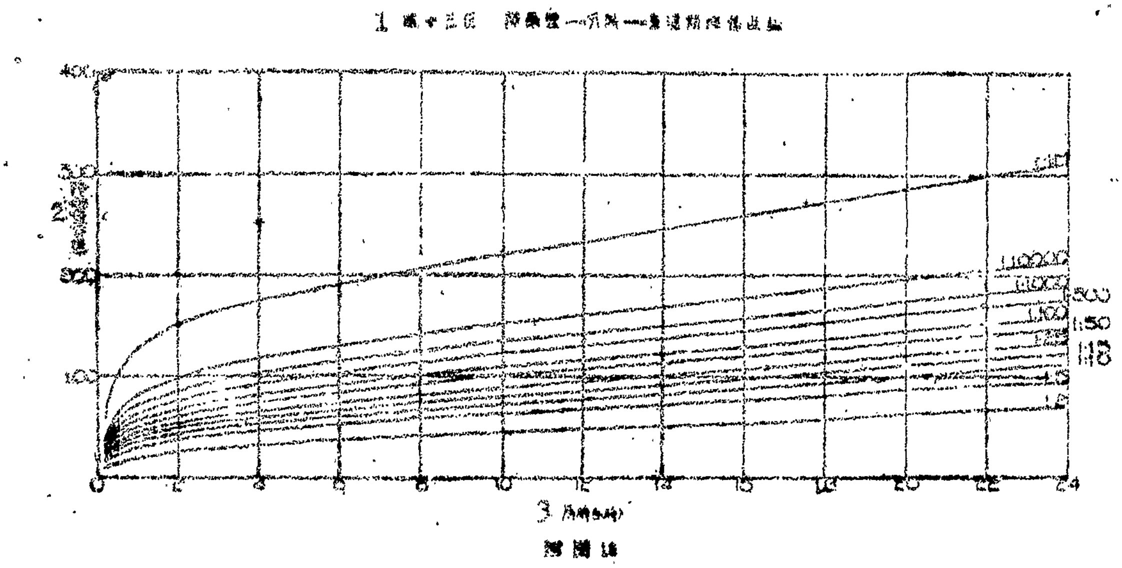
Attached Map 16



附图 17

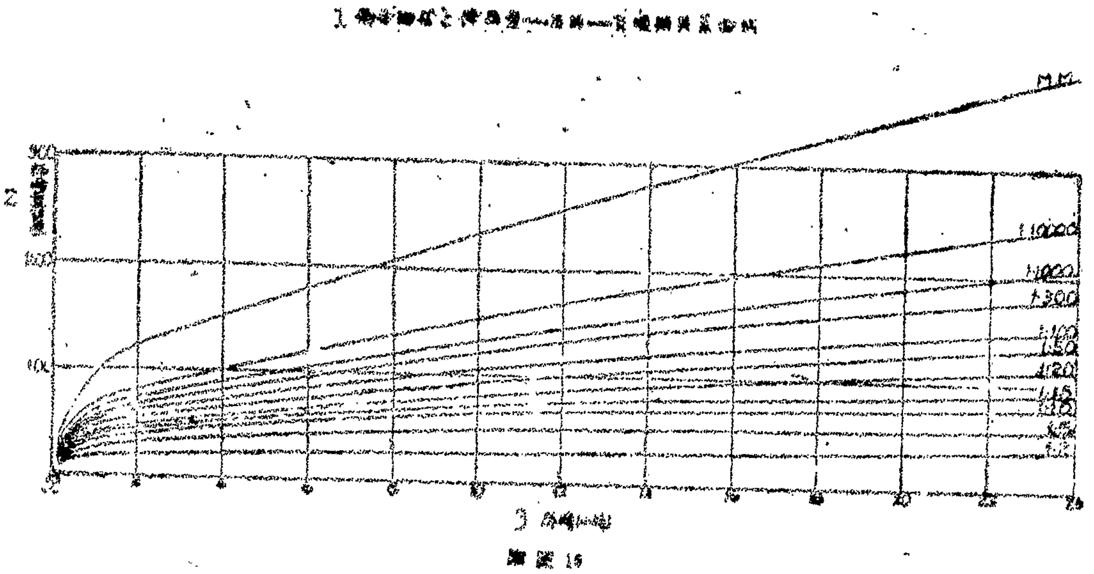
1— Twelfth Region Rainfall-Rain Hours-Frequency Curve
2— Rainfall (in Milli-meter)
3— Rain Hours

Attached Map 17



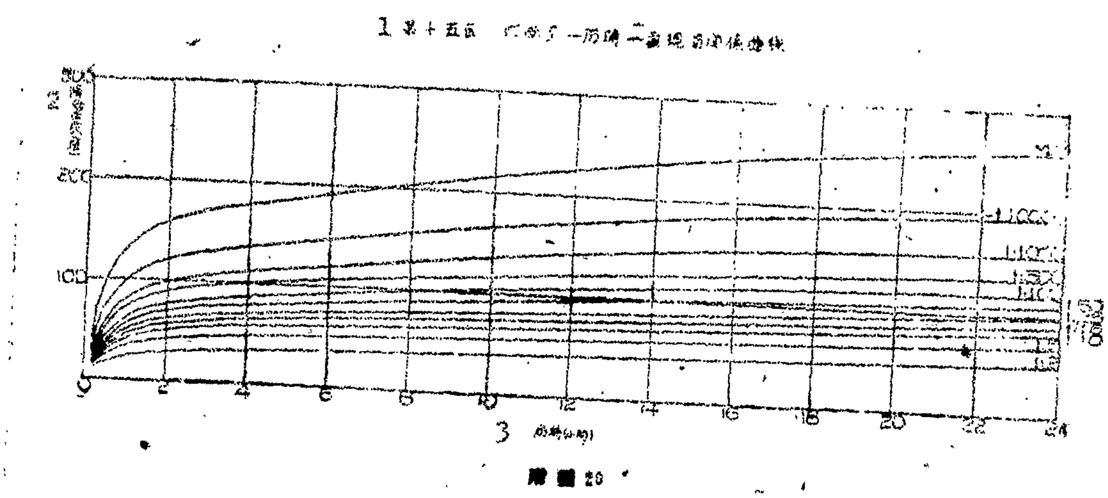
1. Thirteenth Region Rainfall- Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 18



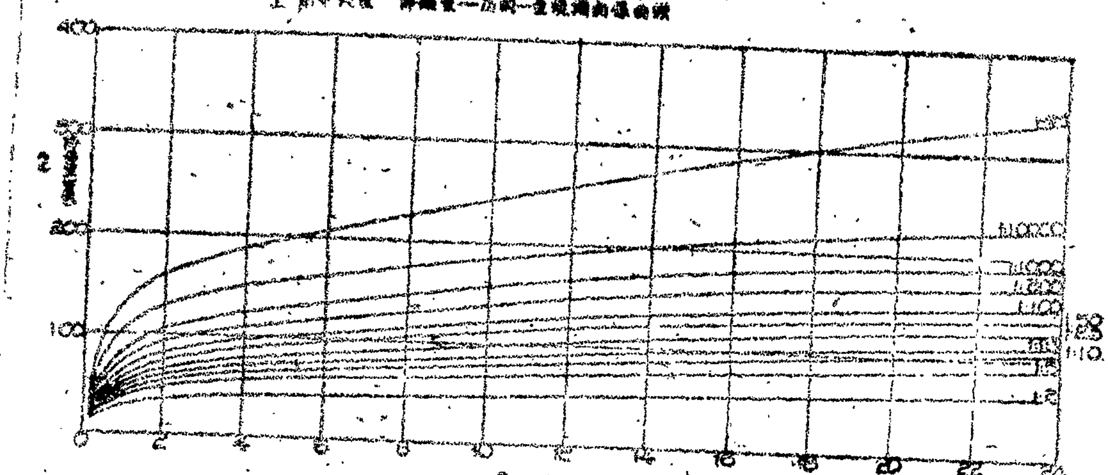
1. Fourteenth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 19



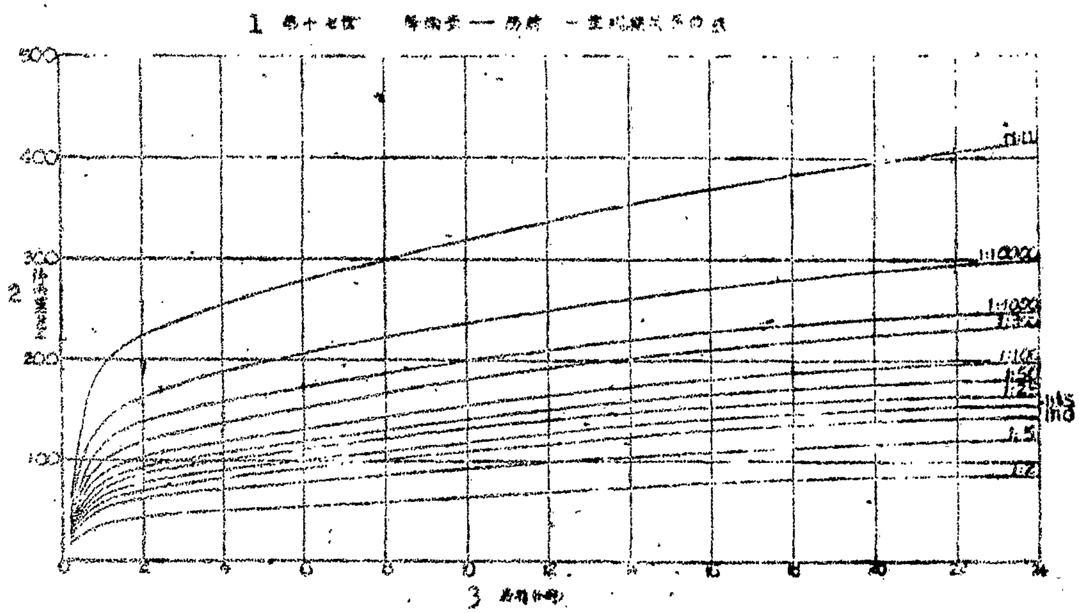
1. Fifteenth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 20



1. Sixteenth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

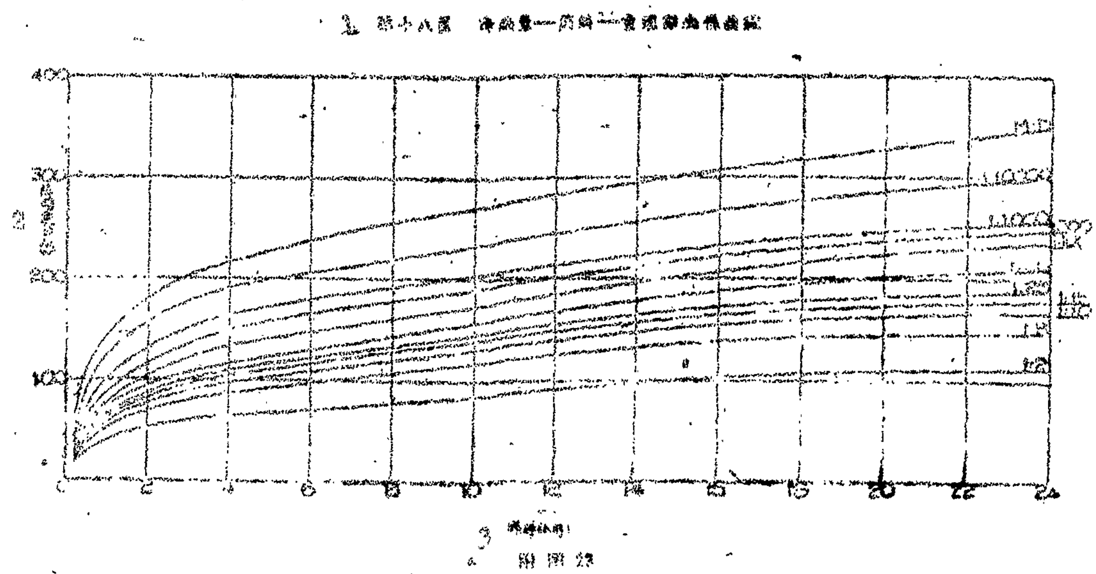
Attached Map 21



附図 22

1. Seventeenth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 22



1. Eighteenth Region Rainfall-Rain Hours-Frequency Curve
2. Rainfall (in Milli-meter)
3. Rain Hours

Attached Map 23

V. PRIMARY REFERENCE BOOKS

(1) The Calculation Standard of the Surface Run-off of Small Basins, translated by the Institute of Railway Research in 1955.

(2) The Research of the Surface Run-off of Violent Rainstorms of Small Basins, by Hsu Tsai-yung (1776 0961 1661), Wu Hsueh-p'eng (0702 1331 7720) and Chu Ch'ing-lin (2612 1987 7792), printed by Jen-min Railway Press.

(3) The Learned Conclusions of the Run-off Section (draft), mimeographed copy of the Institute of Highway Investigation and Design.

(4) Climate of China, edited by Lu Wu (4151 6909), printed by Commercial Press.

(5) China's Climate, edited and written by Ch'en Shih-li (7115 0013 0448), printed by New Knowledge Press.

(6) Rainfall Intensity Formula and the Regulation of the Climate Coefficient, by Sun Chen-t'ung (1327 2182 2639), Wang Kuo-hua (3769 0948 5478), Lu Ch'ang-ch'i (4151 2490 4388), and Ch'en Ch'ing-hua (7115 3237 5478), printed by the Institute of Railway Research.

(7) Violent Rainstorm Data, Part I, printed by Institute of Railway Research

(8) Transmission Through Water Currents, by Ye. V. Boldakov and O. V. Andreyev, 1956 edition.

(9) China Climatic Map

(10) Railway Research Bulletin, Issue no. 17, August 1956, Institute of Railway Research.

(11) Map of China's Violent Rainstorm Parameter, edited by the Institute of Hydraulic Research and the Institute of Hydro-geology.

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